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PLASTICS
and
MOLDED ELECTRICAL INSULATION

BY

EMILE HEMMING

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BOOK DEPARTMENT

The CHEMICAL CATALOG COMPANY, *Inc.*

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PREFACE

That the industry of plastic materials has grown enormously within the past decade needs no proof for even those remotely interested in the manufacture or use of such materials. And, as the initiated know, and as will be abundantly made evident in the pages of this book, the field of plastics is altogether universal in scope, embracing such things as the building of the Panama Canal, with its millions of tons of concrete at the one extreme, and at the other extreme, the filling of a tooth.

Although the industries employing plastic materials are among the oldest in human history, an altogether unprecedented expansion in this field is a comparatively recent event, which must be attributed chiefly to the fact that a variety of new plastic materials have been evolved. In spite of this great activity it is a somewhat singular fact that there seems to be in existence no text devoted to the subject of plastics in general, and the author, therefore, feels that a treatise on the technology of plastics will satisfy a real need.

In the writing of this book, the author had in mind both the general reader and also the specialist. Particular pains have been taken to present in attractive and thoroughly readable form information on a subject which might at first sight appear to be too technical to appeal to the general reader; but the author is confident that this impression is erroneous and that the "story of plastics", in many of its chapters, makes not only instructive but also entertaining reading for the layman, who perhaps often does not realize how large a part plastics play in everyday life. For the specialist the aim has been to state thoroughly the most essential general facts relating to each topic taken up, and to collect together for ready reference all the data from the very extensive patent literature within the last twelve years. The résumé of the patents which will be found at the end of each chapter should prove exceedingly interesting both for technical men working in the field and also for persons interested in the prosecution and litigation of patent cases.

Very special care has been taken in the preparation of the chapter on molded electrical insulating materials, a field in which the author has been personally actively engaged for nearly twenty years, having built up an entirely new manufacturing industry, known to-day in the electrical art as Cold Molded Insulation which was introduced by him in this country in 1908. This chapter is drawn largely from an earlier work of the author devoted solely to the specific work of insulators. Such changes and additions as the lapse of time has

called for have been made and the results of a complete patent search for the last twelve years are also incorporated in this subject.

The author presents this book to the public in the hope that it will find a wide field of utility among technical men as well as appeal to the general reader.

EMILE HEMMING
President, American Insulator Corporation.

NEW FREEDOM, PA.
January, 1923.

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BOOK I

PLASTICS

INTRODUCTION

Broadly speaking, and without attempting to draw any narrow lines of separation, manufacturing operations may be divided into two classes. In the first class are those which are concerned with the making of new materials—as, for example, the extraction of copper from the ore, the production of sulphuric acid by the combustion of sulphur or pyrites, or the raising of an agricultural crop from the natural nutriment in the soil and from the fertilizer spread over the land.

The second class of industrial manufacturing operations is concerned, not with the making of new materials, but with the shaping of products derived from the first class of operations or provided for us ready made in nature.

A most varied assortment of methods of shaping materials is presented to us in the mechanical industries. Wood or metal is cut with a knife, saw, plane, chisel or punch, or turned on the lathe; stone is cut or broken into shape; parts so prepared are assembled and held together with nails, rivets or screws, until the structure desired is obtained. In these cases the shape required is produced by exposing new surfaces with a cutting tool or by assembling separate parts into one whole and holding the parts together by mechanical means.

But from time immemorial man has known also another method of shaping certain materials. The potter's art is almost as old as the human race itself. Now, note on what the success of the potter's art depends: He forms his product while in soft, plastic condition and subsequently hardens it by a suitable process, in this particular case by baking his ware in a fire or oven. He thus avoids operating on a hard material. We have here a general principle capable of the broadest application, and modern industry has not been backward in availing itself of same for the most varied purposes. From the filling of a tooth, to the building of the Panama Canal with its five million cubic yards of concrete; from the manufacture of chewing gum to the pouring of a sea-going vessel, plastic materials do duty: billiard balls, brick bats, umbrella handles, glue, phonograph records, gas burner tips, shoe soles, fine tableware, moving picture films, combs, automobile spark plugs, statuary, collar buttons, automobile tires, roofing tiles, artificial silk, seamless tubing, fiber buckets, rims for eyeglasses, newspapers, children's toys, false teeth—such is a partial list of the motley array of articles produced by the modern industry of plastic materials.

Of the advantages of the employment of plastic materials in forming various articles of common use, one, the most obvious, has already been mentioned: the ease of manipulation.

However there are also several other notable and important advantages. First among these is the readiness with which almost any desired number of more or less exactly similar copies can be made. Of the significance of this in the field of art an object lesson is seen in every sculpture gallery, where replicas of various statues from all parts of the world and from all ages of history can be seen. But of greater importance perhaps, or at least of more practical importance, is the production on a manufacturing scale of large numbers of precisely similar articles. In certain cases industrial conditions require an accuracy of one-thousandth of an inch in the likeness of duplicate parts. Where such requirements are made modern methods can readily satisfy them. In other cases the demands are not so exacting; the manufacturer must select his material and processes with due regard to the exigencies of the trade. We shall have occasion to study examples in point when we come to consider individual cases.

Artificial plastic materials, in particular, offer certain special advantages over natural products for which they often serve as substitutes. They can be prepared of uniform quality in virtually unlimited quantity. Natural materials such as ivory, tortoise shell, horn, etc., present a limit, often small, to the size of the pieces available for use. This limit is greatly extended when an artificial substitute for them is found among plastic materials, and the procuring of such substitutes is one of the fields in which the industry of plastic materials has been particularly active. Another advantage in the use of plastic materials is the great speed with which, under proper conditions, even intricate forms may be produced. A quick motion of a plunger, occupying but a fraction of a second, and the thing is done. Perhaps the most extreme example of this is the stamping or pressing of various articles —sometimes of very considerable dimensions—from metal plates, for many metals, especially when heated, are to be reckoned among plastic materials. Every blacksmith's forge is an illustration of this fact, so is the manufacture of seamless copper tubing by a process exactly analogous to that by which earthenware pipes are made: The warm copper is squeezed out under pressure through an orifice into the center of which a plug, so-called bell, protrudes, this bell forming the bore of the tube.

In a sense and in some degree, indeed, not only many metals but all substances, even the solid rocks of the earth, are plastic. We can apply to them the saying of Heraclites: *πάντα ρεῖ*—"all things flow." A stone slab resting upon supports at its ends is found, in the course of time, to sag in the middle. And, under the immense pressures within the earth crust, slowly acting through the ages, strata are bent, folded and creased like so many sheets of paper. While a certain amount of crumbling undoubtedly takes place in this process, much of the rock mass seems to be bent without breaking. From his laboratory experiments upon the effect of high pressures upon the rock specimens, Professor Frank D. Adams of McGill University concludes that at a depth varying from fifteen miles (in the case of limestone) to thirty miles (granite) there begins what he calls the "zone of flow." Below this

the pressure of the overlying layers is so great that the rocks behave practically like a fluid.

If, in a broad sense, all substances are plastic, only a restricted class of materials combine in themselves the properties which adapt them for use in the industry of plastic materials. The demands made on them vary, of course, according to the particular use to which they are to be applied. But fundamentally, with few exceptions, they must at least comply with the following requirements:

1. **Ready Plasticity.** The force required to mold the material should, preferably, not be too great. In some cases it may be economically admissible to employ even very high pressure, but, other things equal, the need of such high pressure represents an item of cost which, for economic reasons, is to be avoided wherever possible. In those cases where the article, after having been formed, is subjected to further treatment before it becomes hard, it must in provisional form be sufficiently strong to bear the necessary amount of handling.

2. **Hardening Properties.** After the material is formed it must be capable of hardening by some simple process. This hardening may take place in a variety of ways, namely, by cooling a fused or semi-fused mass; by setting at ordinary temperature under chemical reaction (mortar, cement, concrete, plaster of Paris, etc.); by baking or firing (pottery, porcelain, etc.); or by other special processes. For some purposes it is essential that the hardening take place rapidly, so that the molds may be immediately available for re-use. In other cases years may be allowed to elapse in the completion of the process (mortar, concrete). In still other cases setting must be capable of taking place under adverse circumstances: e.g., under water.

3. **Abundance and Low Cost.** Economic considerations set a limit, varying with conditions of use, to the cost of raw materials and of manufacture admissible. The former, in turn, depends, of course, on the abundance of the sources.

From what has been said the reader must have been impressed with the immensity of the field of plastic material. In a comparatively small work, such as this, it is obviously impossible to treat with any degree of detail all the branches of the subject. The author's project is to present, on the one hand, a general survey of some of the most important divisions of the art; and on the other hand, to give a somewhat fuller treatment of selected chapters in which his extended experience in the chemistry and technology of plastics has given him a position of vantage.

Before taking up, one by one, the several topics of our study it will be convenient to take a bird's-eye view of the scope of the entire subject by considering the classification of the various plastic materials employed in the industries. Metals will be excluded, as not coming within the scope chosen for this work.

The plastic materials of industry may be divided first into two main classes: those of inorganic or mineral origin, and those of organic origin. Occasionally mixtures of substances of these two kinds are used.

Among the substances of mineral origin we may distinguish those which are hardened by baking or firing and those which do not require baking but are hardened by simple spontaneous set or various other processes.

Among the organic materials we may distinguish those of animal and those of vegetable origin. A third group are the synthetic organic products. A tabular classification, not including the various classes of molded insulation specifically, may be made as follows:

INORGANIC OR MINERAL		ORGANIC		
Fired Ware	*Cold-Set Ware*	*Vegetable*	*Animal*	*Synthetic*
Ceramic	Mortar	Paper	Horn	Carbolic
Refractory	Cement	Woodpulp	Gelatine	Rubber (Synth.)
Glass	Concrete	Fiber	Glue	
Silica	Plaster	Celluloid	Casein (Galalith)	
	Lime-sand Bricks	Rubber	Shellac	
	Special Cements (Dental, Acid-resisting, etc.)	Resins		
		Asphalts		

CHAPTER I

CERAMIC PRODUCTS

The first place among all plastic materials, both in point of importance to-day and in point of antiquity, must undoubtedly be given to a class of bodies derived from clay. This includes a variety of products applied to a still greater variety of uses. Jugs and pitchers, tobacco pipes, building bricks, drain pipes, basins, roofing and flooring tiles, table china, crucibles for the laboratory and the factory, refractory furnace lining, electrical insulators—such are a few of the examples that readily come to mind. While there is a certain family relation among the different materials of which these products are made—they all have some form of baked clay for their principal constituent—yet they vary in their character and properties over a wide range.

At the one end of the scale we have such coarse-grained, porous materials as go to make up a flower pot or a brick; at the other end we have fine china, close-grained, impervious, of a pure white color, or delicately shaded at the maker's discretion and—a typical characteristic of porcelain—translucent. Intermediate between these two extremes we have a variety of glazed and enameled materials, as used for common tableware and art pottery, and common stoneware, approaching porcelain in its close-grained, impervious character, but unlike porcelain, wholly opaque.

The texture of the ceramic products depends both on the character of the clay and other materials employed in its manufacture, and also on the mode of firing, the temperature to which the heat is raised. This latter itself depends on the particular raw materials used. Not all clay bodies can be heated without losing their shape, to the point at which the pottery begins to fuse into a hard, compact, impervious mass. Materials which lack this property may, however, still be employed for the manufacture of pervious types of ware, glazed or unglazed.

The Raw Materials of the Ceramic Industry.—1. *Clay.* As already indicated, the principal raw material in the manufacture of ceramic ware is one or other of the somewhat varied forms of clay found in nature. Clays are the result of the weathering of certain igneous rocks, such as granite. Such rocks consist of silicates of soda, potash, lime, alumina and iron. By prolonged action of rain and atmospheric carbon dioxide the other constituents are dissolved or washed away, leaving behind a more or less pure aluminum silicate, that is to say, a clay. This substance is then either found in the place in which it was thus formed (so-called primary clays), or it may be washed along by rain and running water and redeposited elsewhere as a secondary clay.

From the mode of formation of clays we would naturally expect that they should vary considerably in composition and in their general character. Clays containing a considerable amount of lime are commonly spoken of as marls. Clays deposited in clearly discernible layers are known as shales, or, if consolidated by pressure, as slate. Clays very free from alkalies and lime are known as fire-clays and are used in the manufacture of refractory ware, owing to their infusibility. Generally, it may be said that the presence of alkalies, lime, magnesia and iron tends to increase the fusibility of a clay, while an excess of silica raises the temperature of fusion.

A very pure white clay known as China clay or kaolin is the fundamental raw material used in the manufacture of porcelain.

2. *Other materials added to the clay.* The natural properties of a clay, in so far as they are significant for its application in the manufacture of ceramics, can be modified in various ways by the addition of other substances. For example, if a more refractory product is desired than would result from the use of the native clay, silica in various forms may be added. For this purpose ground quartz, flint or sand may be used. If, on the contrary, it is desired to reduce the temperature required for firing the ware, the mass may be rendered more fusible by the addition of fluxes, such as salts of the alkalies, in particular their silicates or borates; the alkalies may also be added in the form of feldspars, which are natural silicates of the alkalies and alkaline earths.

A clay may be too plastic. In such case there is too great shrinkage in the firing. This may be remedied by the addition of various "opening" substances. A substance commonly employed for this purpose, from antiquity, is so-called "grog," that is to say, ground up ware from a previous firing. Silica, particularly in the form of sand, in addition to raising the fusing point, also acts as an opening substance. Lime has a similar effect, and is commonly added in the form of marl.

Mixing the Ingredients. When other ingredients are added to the clay, they first must be reduced to fine powder in a suitable grinding mill or cylinder. Both the grinding and the mixing may be done either wet or dry. The latter method of mixing facilitates somewhat the accurate gauging of the proportions of the ingredients, although clays always retain a somewhat indefinite amount of moisture, so that accurate control of quantity is not an easy matter.

For finer grades of pottery and porcelain the materials are made into a thin paste or liquid (slip) with water, and this is then sifted through metal sieves or bolted through silk to remove coarse particles. The slip is then put through a filter press in which the excess of water is extracted, leaving in the bags of the filter, cakes of plastic clay. These cakes are put through a pug mill to insure uniformity throughout the mass. The clay body is then preferably allowed to season or age as this is found to improve its plastic properties.

The Manufacture of Pottery. As already remarked, the manufacture of ceramic products is one of the very oldest industries, dating back to prehistoric times. Buried deep under Nile muds, baked bricks

have been found, whose age, judging by the thickness of overlying strata, has been estimated to be ten thousand years.

Some of the prehistoric pots and vases were molded simply by hand, often with much skill. But in very early times the "potter's wheel" came into use. This is a sort of turn-table upon which the article to be molded is placed. A swift rotation is given to the table, which is mounted upon a pivot, and the hand applied to the side of the articles sweeps it into the desired form. This operation is clearly illustrated by a painting found in an Egyptian tomb at Thebes, dating from about 1800 B.C. From the marks left on fragments of pottery found elsewhere, we know, however, that the potter's wheel was in use in Egypt as early as 4000 B.C. An improved form of wheel is also of very ancient origin, and is known to have been in use in the time of the Ptolemies. Here the rotation is imparted to the wheel by the foot placed upon a disc near the bottom of the device. Wheels of both these types, hand driven and foot driven, are still in use at the present day, side by side with mechanically driven wheels, over which they have the advantage in that the speed is more perfectly controlled by the operator.

A very ingenious artifice sometimes employed in connection with the potter's wheel is what is known as "cord throwing" (the operation of forming clay bodies on the wheel is technically known as *throwing*). In making elongated bodies of considerable dimensions some kind of a core is needed to support the clay. A temporary core is then made by wrapping a cord around a rod, the thickness of the wrapping following approximately the outline of the body to be formed. To this core the clay is then applied and shaped in the usual way upon the rotating wheel. After the piece is completed and has been allowed a little time to set, the cord is then pulled out, leaving a hollow body of the desired outline.

Certain pieces of pottery, after having been allowed to harden somewhat by standing, are finished on a lathe.

An entirely different method of forming pieces of pottery is that known as "casting." In this case the clay is used in the form of a thin liquid, termed "slip," which is poured into a plaster mold. The plaster absorbs much of the water, and a layer of clay is thus deposited on the inside of the mold. When it is judged that this layer is thick enough, the surplus slip is poured out and the clay in the mold is left to harden for a while. The mold can then be taken off, leaving the hollow article ready for drying and firing.

For a certain class of objects, such as bricks, tiles, pipes and hollow bricks, another method is commonly employed. A fairly stiff body of clay is forced by machinery through a die from a container or cylinder. A long ribbon is thus squeezed out, which is cut into sections of suitable length by a mechanical cutter. The bore of pipes or hollow bricks is formed by a plug, known as a bell, placed inside the cylinder in appropriate position.

Many articles of pottery and china or porcelain are also formed by pressing the clay in molds, either by hand, or by machine power. In the modern state of the art it is possible to prepare even quite intri-

cate pieces in this way, though the operation of pressing, especially for thin walled articles, requires great care. The clay for molding is commonly used in the form of a fairly stiff body. In some cases, however, as for instance in making certain tiles and electrical insulators, the clay is used in the form of a powder, containing just enough moisture to cause it to adhere together to a fairly solid cake when subjected to a high pressure in a mold.

The molded articles are stacked up to dry for a time, and are then burned in kilns at a temperature depending on the material employed, and ranging, for hard porcelain, up to 2000° C., a dazzling white heat. A proper control of the temperature is a most important factor for success, and great skill has been developed by manufacturers in this respect.

Owing to the considerable shrinkage of porcelain in the firing process, it is evident that wide practical knowledge of the behavior of various shapes in the kiln is essential in order that the final product may be of the form and dimensions originally designed. It is worthy of remark that this art has undergone such development as to render possible the production of parts of very complicated design.

Though not strictly belonging to the class of materials we are here considering, mention may be made of a plastic known as "Lavite." It is made from the waste from the cutting of slate or of soapstone. The powdered material is mixed with a solution of sodium silicate. The mass is dried, powdered and molded in dies under pressure after the addition of sufficient water. The molded articles are then fired at high temperature, and after cooling are again treated with alkaline silicate solution and fired again. This operation is repeated until the absorption of the alkaline silicate ceases.

The finished products are very hard and tough and somewhat similar to porcelain. They resist sudden changes in temperature better than porcelain and are, therefore, more desirable for certain articles, such as electrical insulators and tips for gas burners. Their great shrinkage during firing and the consequent difficulty in obtaining accuracy in the finished molded form is their principal drawback.

Special grades of lava composition are made for resistance insulators, and for this purpose are unexcelled. "Lavite" articles such as mentioned above, are not as yet produced to a great extent in this country. Most of the "Lavite" used in the United States is cut or worked out from soapstone and then fired.

Glazes and Glazing. The field of application of pervious fired clay products is limited. In the case of crude pottery and bricks the rough finish is no objection, and the permeability may be actually an advantage—e. g., flower pots.

But in the majority of cases a smooth finish and impermeability are desirable or indispensable. As has already been observed, certain clays are capable of sintering to a compact, impervious mass at temperatures at which they still retain their shape. But in the majority of cases this is not so, and it then becomes necessary to impart the requisite finish and impermeability to the product by coating it with a glaze. A glaze may also be imparted for decorative or other

purposes to bodies which themselves have been fired to an impervious product.

1. *Salt Glaze.* The simplest method of glazing consists in throwing wet salt (NaCl) into the furnace toward the end of the firing. The salt decomposes at the high temperature of the furnace in contact with the moisture, and the alkali liberated combines with the free silica of the pottery ware, forming a glaze. This method is applicable only to bodies containing considerable excess of silica uncombined with alumina.

2. *Lead Glaze.* Common red and brown pottery is coated, before firing, with red lead. In the subsequent firing the lead enters into union with the silicate of the body and forms a bright glaze.

3. *Silicate Glazes.* More commonly glazes composed of silicates of alumina and an alkali or alkaline earth are employed. They may also contain lead or zinc, and the silica may be partially replaced by boric or titanic acid.

These glazes may be applied in various ways (dipping, spraying, dusting, etc.) either to the unfired articles, or after a moderate preliminary heating, or after firing to high temperature, and are then fixed by firing.

Coloring of Ceramic Ware. Both the clay body and the glazes are susceptible to coloration. The commoner clays are naturally colored yellow, red, brown, gray or black by various impurities, notably iron and organic matter. Those clays which give white bodies may be colored by the addition of various substances: a blue color is obtained with cobalt, green with cobalt and chromium, blue-green with cobalt and zinc, yellow with titanium, black with iron and cobalt.

Similarly, various colored glazes are obtained by the addition of cobalt (blue), copper (green), iron (yellow), and manganese (brown).

Enamels are glazes rendered opaque by the presence of oxide of tin.

Colors for decorating porcelain and earthenware are of two types: The so-called "underglaze" colors are applied to the ware before glazing so that they are covered by the glaze. They consist of various metallic oxides, chromates or silicates mixed with China clay, etc.

The "onglaze" colors, on the other hand, are applied after the glaze. Naturally the onglaze colors are less durable than the underglaze colors. They consist of silicates, with or without borax or boric acid, of various metals.

Refractory Materials. There is a certain class of fire-hardened plastic materials which are grouped together, not by their composition and method of production, but by their application. These are the so-called refractory materials. In origin and mode of production some of these are closely related to the ceramic clay products, while others are more nearly akin to the cement and concrete products which we shall consider in a later section. In their use they have this in common, that they must be capable of withstanding high temperatures, coupled, in the majority of cases, with other destructive influences, such as the gases of furnace flames or of the flues leading from furnaces, flue dust carried in such gases, slags produced in various metal-

lurgical operations, etc. The bricks and cements used in the construction of such structures must not only resist for a reasonable length of time the corrosive influences, at high temperatures, of the materials coming in contact with them, but must remain sufficiently strong to support the loads placed upon them; they also must not shrink unduly (clay products in general shrink under the action of continued high temperature); in the case of some structures a moderate expansion with heat is not objectionable, for others a condition of constancy of volume must be approached as nearly as possible.

There is no one material which will fulfill all these conditions under all uses. The choice must be made in each case to suit the conditions of the particular case.

The importance of refractory materials to all industries and, in consequence, to everyday life, is not generally realized. Without them the use of gas and electricity as sources of power would be impracticable; the production of steel, copper and other metals could not be accomplished; even our steam power plants could not exist without them. Especially in certain of the most recently developed industries the great progress made of late years has been rendered possible largely by our modern resources in refractory materials, and if this progress is to continue, the art of making and using refractory materials must itself be developed *pari passu* with the industries dependent upon it. So, Searle points out, "the production of the highest qualities of optical glass and of certain rare elements, such as tungsten, used in the production of special steels, is impeded by the lack of materials of sufficient refractoriness, and users of electric furnaces are hampered by their inability to obtain linings which satisfy their exceptionally severe requirements."

For details regarding this special branch of the industry of plastic materials the reader must be referred to works devoted entirely to that subject, such as Searle's work, just quoted. We shall here pass in brief review some of the standard refractory materials in common use.

Nearest akin, among these, to ordinary ceramic ware, is the so-called fire-brick.

Fire-brick. While this term might be understood to refer to refractory bricks generically, it is commonly restricted to denote refractory bricks whose chief constituent is fire-clay. Fire-clays are clays rich in silica, with a correspondingly high fusing point. They may be used either alone or in combination with other substances, to make refractory bricks by methods precisely similar to those employed in the manufacture of ordinary bricks. The fire-clays are commonly found interlarded with coal deposits, and it had been suggested that the reason for their high content of silica is that they formerly were the soil on which the plants, fossilized into coal, grew; the alkalies were thus extracted from them, leaving a material rich in silica. This supposition seems to be borne out by the fact that the roots of such plants are sometimes found in the fire-clay deposits. There is, however, considerable doubt as to the correctness of this explanation. In some cases the material contains 90 per cent or even more of silica, so that it is hardly justifiable to

call it a clay. This is true, for example, of the so-called ganister of the British coal mines, much used for the manufacture of fire-brick, and slightly plastic, though containing only about 10 per cent clay or less. Such a material as this cannot be used alone for the preparation of bricks, though it may be very serviceable in combination with more plastic clays. By properly combining together two or more fire-clays the requisite plasticity and a minimum shrinkage in firing can be secured. It is also common practice to mix in a certain amount of so-called "grog," that is to say ground fire-brick.

Grog Bricks. Grog may also be used as the principal constituent of fire-bricks, bonding it together, not with fire-clay, but with a highly plastic clay.

Grog fire-bricks have an advantage over those made from fire-clay, in that they hardly shrink in use, for in the preliminary burning of the grog a temperature can be employed much exceeding that to which the bricks will subsequently be subjected. They are at a slight disadvantage in point of cost, except in localities where waste is available for use in making the grog.

Clay Silica Bricks. These are made from ground silica rock bonded with clay in much the same way as the grog in the grog brick just described. They are remarkably constant in volume under the influence of heat, being in this respect intermediate between fire-bricks made from fire-clay, which shrink with heat, and the silica bricks to be described presently, which expand. They also stand a greater load at 1350° C., without deformation, than do bricks made of fire-clay alone.

Sand-lime Bricks. This is a product more nearly akin to the group which we shall consider in our next chapter, the calcareous cements. It is, however, mentioned here because, when intended for refractory use, it is prepared by firing, while most of the materials of the second group set to a hard mass without firing.

Sand-lime bricks are made by bonding sand together with slaked lime. Such bricks will not set hard spontaneously like Portland cement; they will, however, harden without actual burning, on treatment with steam under pressure. If they are to be used for refractory purposes, they must be fired at a high temperature.

Sand-lime bricks expand with heat, and are therefore used where absence of shrinking is essential, particularly in the arches and crowns of furnaces of different kinds. They have found particularly wide application in the construction of coke ovens.

Magnesia Bricks. These are made from magnesite (magnesium carbonate) which has been converted into magnesia or magnesium oxide by heating to a high temperature. The product obtained, so-called "dead-burned" magnesite, is bonded by means of a paste of caustic magnesia and water. The body so prepared is formed into bricks in a press at from 3500 to 7000 pounds per square inch.

Magnesia bricks are a typical example of a basic brick, being in this respect diametrically opposed to fire-clay and silica clay bricks, which are acid in character. Accordingly a magnesia brick lining will be stable in the presence of basic slags or other basic materials that may be

present, while it will be corroded by acid substances; exactly the reverse is true as regards the acid types of brick, fire-brick and silica bricks.

Bauxite Bricks. This is another basic brick. Bauxite is a mineral consisting of a hydrated oxide of aluminum. The bauxite rock is first burned at about 1400° C. or over and is then crushed to a coarse powder, which is made into bricks with a suitable bond, such as clay (preferably a small quantity of plastic clay), or lime. The bricks are then dried on steam-heated floors and burned at a temperature of not less than 1250° C., preferably 1400 to 1500°.

Bauxite bricks are highly refractory, but labor under the disadvantage that they shrink continually in use at high temperatures.

Alundum Bricks and Alundum Cement. Alundum is the name given to a very refractory material obtained by fusing bauxite in the electric furnace. When bonded with clay or cement it can be made into bricks or other articles (crucibles, etc.), infusible at 1950° C. Alundum cement made from alundum and a small proportion of clay is placed on the market in the form of a dry powder which is made into a paste with water as required.

Carbon Bricks. Coke or graphite bonded together with clay or pitch makes a brick serviceable for certain purposes; such bricks are used, for example, in the steel industry.

Chromite Bricks. Very excellent refractory bricks are made from chromite or chrome iron ore, a mineral having approximately the composition corresponding to the formula, Cr_2O_3FeO. Various bonds may be used, such as clay, lime, bauxite, tar, etc. Chromite bricks are highly refractory and neutral in character, being resistant both to silica and also to slags. Their cost, however, is high.

Carborundum and Allied Bricks. A number of highly refractory products are obtained by fusing silica together with carbon in the electric furnace. These bodies are carbides (carborundum, SiC) or carboxides (silixicon Si_2C_2O) according to the proportion of carbon present in the charge employed in the reduction. These can be made into bricks with various bonds or even without bond. The bricks are too expensive for commercial purposes and therefore do not find much application outside of experimental work.

Refractory Mortars or Cements. The same materials which are employed for the manufacture of various refractory bricks are also, generally speaking, adapted for use as mortars or cements to bond the brickwork into furnace structures and the like. In fact, it is obviously desirable to use in each case a mortar similar in character to the bricks employed; it would evidently be quite out of the question, for example, to bond acid bricks together with a basic cement or vice versa.

Among cements commonly employed the following may be mentioned: Raw fire-clay, alone or mixed with sand or grog; sand and crushed fire-brick with lime or Portland cement; burned magnesite bonded with waterglass (sodium silicate) or with tar.

Refractory Porcelain. Porcelain vessels (crucibles, basins, tubes, etc.) are much used in the chemical laboratory under conditions requir-

ing highly refractory qualities, and also considerable resistance to somewhat sudden changes of temperature.

Special porcelains in considerable variety are manufactured expressly for this and similar uses. Some of these closely resemble ordinary porcelain in composition and mode of manufacture, the refractory quality being secured by the introduction of calcined alumina, or, in some cases, calcined magnesite, into the mixture. Searle quotes, for example, the following proportions:

Best China clay	30 parts
Feldspar	25 parts
Alumina	45 parts

The well known Berlin porcelain for laboratory ware has the following composition:

Silica	69.5
Alumina	26.6
Iron Oxide	0.8
Titanium Oxide	0.4
Lime	1.4
Magnesia	0.3
Potash	0.3
Soda	0.7

Another class of porcelain owes its refractory character to the presence of magnesia; a mixture of this character recommended by E. T. Montgomery [1] is

Ball clay	30 parts
Georgia Kaolin	20 parts
Fused Magnesia	50 parts

Porcelain for Spark Plugs. Porcelain for spark plugs for automobile and airplane motors is called upon to satisfy very special conditions. It must not only withstand high temperatures, but must also be insensitive to mechanical shock. It must not be subject to any considerable change in volume or in electric resistance with temperature change.

A. V. Bleininger and F. H. Riddle, in a study conducted at the Bureau of Standards,[2] have investigated the relation of the composition of porcelain to these qualities. They conclude that in such cases the use of feldspar as a flux is injurious as is also the presence of free quartz in the mixture employed.

They recommend replacement of the feldspar by double silicates of magnesium and aluminum, or of beryllium and the alkaline earths. Instead of quartz they recommend that calcined kaolin, alumina, zirconia or sillimanite be used.

[1] *Trans. Am. Cer. Soc.*, 225, pp. 606-619.
[2] *Jl. Am. Cer. Soc.*, v. 2, July, 1919.

Steatite Porcelains. The mineral steatite, also known as talc or soapstone, is a magnesium silicate. This can be made into a refractory porcelain-like body by grinding to powder, making into a paste either with water alone, or with the addition of a suitable bond, such as fire-clay. Feldspar may also be added as a flux.

The body so obtained is molded in a press and fired. Such steatite porcelain has been much used for electrical insulators.

PATENT REFERENCE

CERAMICS

G. P. 274,039/10 Schwerin. Highly resistant products from materials in themselves not plastic. Non-plastic material, e.g. carborundum is ground as fine as possible, boiled with hydrochloric acid or aqua regia, filtered and washed, boiled with soda lye, and with hydrofluoric acid if silica remains. With foreign matter thus removed, the material is suspended in water and converted into the colloid state by a little ammonia. This suspension is separated into different grades of fineness. The finest particles are removed by electro-osmose. The product obtained is molded or poured, then dried and burned.

B. P. 14,235/12 Schwerin. Articles of ceramic refractory material are made from material not naturally plastic, other than corundum or carborundum, by special treatment.

G. P. 274,847/12 Podszus. In the manufacture of thin ceramic products from materials not containing clay, the initial materials used are thorium oxide, zirconium oxide, rare earths, alumina, silica, boron nitride and coal. A form is coated with a thin layer of paraffin, ceresin, wax, or ozocerite, and is then coated with the ceramic mass, and after this is solid, the form is heated, and the paraffin layer is melted out.

U. S. P. 1,058,065/13 Gerber. In the manufacture of ceramic masses, finely ground iron-free earthenware scrap 40 is mixed with finely ground porcelain chips 60. Upon thorough burning, white sintered porcelain-like scrap which is quite firm is obtained. This mass, in a roughly ground state, is dry pressed under 50–100 atmospheres to plates, etc., but may also be formed in the wet state.

B. P. 16,684/13 Sablon. A porous ceramic material made from asbestos and steatite or their equivalents is used in fragments about 1 mm. in size as a filling for primary and secondary cells. A mixture of 70 parts of asbestos or other double silicate of calcium and magnesium and 30 parts of steatite or other silicate of magnesium is baked, crushed, and freed from large pieces and dust.

Can. 145,606/13 Laufer. Processes for the production of artificial stones from material rock wastes, consisting in mixing aluminum and sodium phosphates with porphyry, basalt, granite and the like in coarse and fine granulations, the mixture being then compressed and molded in a slightly moistened state and burned.

G. P. 276,003/13 Grunstadt. Writing tablets of pottery ware are made of a mass consisting of an alumina-lime magnesia-silicate mixture which is burned at a low heat, and the burned plates are coated with a lead-boron-zinc silicate mat glaze and burned again, at a high temperature.

G. P. 278,594/13 Singer. In making spark plug porcelain, and the like, the composition of the product is determined with a view of utilizing the broken used articles, the essential constituent being lime hydrate added in definite proportions to the porcelain base. A calcium aluminate results upon burning.

G. P. 294,661/13 Albert. Coke or ceramic masses are mixed with emulsions made of tar, heavy tar oils, fatty oils, or the like, and thickened sulphate waste liquors. Aqueous emulsions of molasses, starch paste, glue, sugar, etc., may also be used. Various rock masses, clay, kaolin, magnesia, and lime mixtures when heated with these binders form acid-proof products.

U. S. P. 1,096,688/14 Dantsizen. Making wear-resisting articles such as dies for working metal, by compacting alumina with a binder such as gum tragacanth, baking to slightly sinter, then shaping it into the desired form and firing at about 1800 deg. C. The product is noncrystalline, takes a high polish and withstands sudden change of temperature without cracking.

U. S. P. 1,107,011/14 Allen. Making molded articles of granular fused alumina

by mixing the alumina with about 5% its weight of a 20% solution boric acid in glycerol, molding and heating to at least 1300 deg. C.

U. S. P. 1,107,012/14 Allen. Making molded articles from crystalline alumina by mixing it with about 5–10% of aluminum hydrate with or without a solution of boric acid in glycerol, molding and heating to at least 1200 deg. C.

U. S. P. 1,116,979/14 Borner. Colored plates for architectural ornaments are formed by molding a mixture of lime or magnesia or water-glass, feldspar and sand into the desired shape, painting with ceramic and glass-colors, and burning at 800–1000 deg. C.

U. S. P. 1,119,543/14 Sabine. Sound-absorbing ceramic material for walls and ceilings, having a sponge-like porous surface portion.

G. P. 292,645/14 Strack. A mixture of clays containing syenite is formed, dried, and ground, mixed with finely ground syenite rock, and this mixture is compressed with some water and burned. Other clays may be added to produce special products. Iron brick, floor tiles, street paving, stoneware, etc., are made.

U. S. P. 1,130,794/15 Clark. A roller-skate wheel is made with a tread of porcelain 32 parts hardened and toughened by the addition of white arsenic 1–2 parts and silica 8–16 parts.

U. S. P. 1,131,463/15 Berry. Ceramic ware is formed by molding under pressure a moist mixture of china clay, talc and sodium silicate, air-drying, baking at about 130 deg. C, machining, and firing at about 800 deg.

U. S. P. 1,203,011/16 Kirk. A slip for casting earthenware articles is made of china clay, flint and spar mixed with a previously blunged ball clay mixture containing soda and sodium silicate.

U. S. P. 1,228,465/17 Minton. An unvitrified and strongly weather-resisting terra cotta is formed of stoneware clay 30, low grade fire-clay 30 and slag, high in silica, low in lime and substantially free from iron, 40 parts.

Can. 177,106/17 Wagner. Sewer pipe and tile are made from a mixture of coal ashes, crude fibrous asbestos, water glass and water, molded and burned.

Can. 177,107/17 Wagner. Brick and tile are made by mixing coal ashes 0.39 cu. yd. crude fibrous asbestos 0.01 cu. yd., and water 35 gals., molding and burning.

U. S. P. 1,251,888/18 Horn. A ceramic composition for porous articles is made of a mixture of about equal amounts of powdered burned fire-clay and loam clay, high in alumina and low in silica, lime, magnesia and alkalies, which is moistened, molded and baked. It is used for heating elements through which steam or water is passed.

U. S. P. 1,255,878/18 Hayde. Bricks or similar articles are formed from a mixture of cement, lime and water with a material prepared by burning clay, shale or shale rock containing gravel, sand or chalk at 800 deg. or higher, treating the burned material with water and crushing it.

U. S. P. 1,263,039/18 Clemen. A resistance composition suitable for use in self-starting devices for electric motors is formed by mixing clay 1 part, finely divided iron 1 and carborundum 0.25 part, adding water to form a paste, molding and firing at a red heat.

U. S. P. 1,273,547/18 Sharples. Artificial stone is formed by mixing pre-heated disintegrated silica sand, carborundum or alundum and disintegrated glass or slag, forming and pressing the mixture and heating it to a temperature above the fusing point of the glass. Molasses or stale beer may be used as a binder in molding.

U. S. P. 1,275,705/18 Laird. Hydrating clay which has been freed from iron by forming the chloride is subjected to the action of steam at 500–700 lbs. pressure and 200–250 deg. to increase its plasticity.

B. P. 130,134/18 Roberts. Tiles, bricks, sanitary ware, etc., are made from slate or shale dust, chippings, or fragments (85–70%) mixed with a lightening material in the form of magnesium talc or steatite (15–30%). The materials may be mixed

with water, molded and baked; or they may be fused, in which case 10% or more of a flux such as soda ash or fluorspar may be added.

U. S. P. 1,292,953/19 Jeppson. Fused granules of alumina of different sizes are embedded in a ceramic clay mixture in making "anti-slipping" tiles.

U. S. P. 1,312,853/19 Kohler. Basic aluminum sulphate is generated within a mass of clay by adding ½–5% of aluminum sulphate in order to increase the plasticity and bonding properties of flint clays, etc.

U. S. P. 1,318,960/19 Bolt. A brick suitable for furnaces of steel mills is formed of clay 25% and roll scale 75%.

B. P. 138,799/19 Gronroos. Nearly equal parts of porcelain or faience refuse, powdered pipe-clay, and crushed glass are mixed together with a little water and poured into a mold, the bottom of which is covered with crushed glass. Pressure of about 2850 pounds per square inch is applied and the material is then exposed to a temperature of 900–1200 deg. to produce an artificial stone or marble-like slab having a glazed surface. Variegated effects are produced by using colored glass.

U. S. P. 1,345,632/20 Purdy. Porous bricks suitable for furnace linings are formed by burning a lignite clay mass, which may also contain kaolin, refractory ball clay, "high alumina" clay and burned clay grog.

U. S. P. 1,346,959/20 Hinckley. A material suitable for furnace linings, hearths, etc., is formed of fully shrunk graded carbon particles in mutual contact with a ceramic bonding material such as finely ground clay.

B. P. 141,351/20 Assie. A refractory and abrasive product is made by heating bauxite with sufficient carbon to reduce all oxides other than alumina and a proportion of chromium oxide. The mixture on fusion gives a slag chiefly consisting of alumina crystals joined together by a chrome oxide cement and an iron alloy separable by hand or magnetically. The quantity of chromium oxide should be sufficient to enable the whole of the iron oxide to be reduced, but not so much as to produce an alloy.

B. P. 144,317/20 Walter. Small quantities of neutral or alkaline vegetable extracts are added with alkalies to clay or kaolin masses, or non-plastic materials which are liquefied with difficulty by the addition of alkali alone. Neutral, water-soluble saponins or extracts of saponin-bearing plants such as seatwort, cookweed, sowbreads, ivy and chestnut-capsules are especially suitable. Alkaline cellulose waste lyes and "cellular pitch" can also be used.

MAGNESIA REFRACTORIES

B. P. 16,096/10 Mason. Refractory bricks, blocks, tiles, and the like are made by adding a suitable proportion of powdered basic slag as a fluxing agent to calcined powdered magnesite.

B. P. 26,913/12 Sefton. Fire-bars are made of fire-clay and quartz, with or without the addition of magnesite or kieselguhr. Magnesite increases the temperature that the bars will stand, while kieselguhr restores elasticity lost by the introduction of the magnesite.

G. P. 290,799/12 Grundmann. Binding qualities are imparted to low-grade burned magnesite by treatment with steam or water.

G. P. 222/13 Baker. A furnace building material is obtained by first burning dolomite in alternate layers with coke in a shaft furnace, grinding the burned product, and again burning it with combustion residues as sintering materials. The product can be used in the lining of metallurgical furnaces, for stopping tap holes, for the preparation of furnace bottoms, etc.

G. P. 294,021/14 Krieger. Refractory stone masses are made by burning dolomite with quartz or magnesium silicate to change all the calcium to silicate and leave free magnesia.

U. S. P. 1,160,085/15 Meyer. A lining for basic open hearth furnaces is formed when granulated dolomitic limestone is calcined and then heated to its sintering temperature, cooled, and mixed with sufficient granulated basic open earth slag to fill the voids in the sintered material and act as a binder.

B. P. 15,163/15 Twynam. Refractory bricks are made with a single burning by mixing and grinding magnesite, dolomite, limestone, or lightly burned magnesite with not less than 20% and not more than 80% of chrome iron.

U. S. P. 1,205,056/16 Stowe. F. P. 483,922/17 Stowe. Basic refractory bricks for use in lining furnaces are formed by grinding together magnesite, hematite, and water, molding the mixtures, burning to drive off carbon dioxide and water and to combine the magnesium and iron oxides; crushing, grinding again with water and again molding and burning.

U S. P. 1,240,148/16 Kennedy. Refractory basic bricks having a vitrified surface and suitable for furnace linings are formed of particles fritted together and composed of lime and magnesia 78–92 and silica 2–13 parts with a small amount of a fluxing agent such as iron oxide and alumina.

B. P. 102,386/16 Twynam. Refractory bricks and cement for furnace linings are made by mixing 3–10% of slag-wool with dolomite magnesite, or limestone, and firing at a high heat. A less porous brick is obtained by adding 20–30% of highly shrunk ground magnesite to the carbonate and slag-wool mixture, or by grinding the burned bricks, remolding, and again firing.

B. P. 110,147/16 Stowe. Magnesite is mixed with iron oxide (as, rolling mill scale), ground, moistened and molded into bricks, burned to expel carbonic acid and to combine the iron and magnesium oxides. The crushed material may be used for furnace linings or new magnesite, magnesia, or iron oxide added and the process repeated. Bricks, crucibles, thermite molding gates, etc., are made.

U. S. P. 1,210,431/17 Davison. Furnace-linings are formed of granules of hard burned dolomitic lime impregnated with such a small amount of basic slag that their faces are substantially free from any layers of the slag.

U. S. P. 1,230,430/17 Patnoe. A refractory material suitable for furnace linings is made of magnesian limestone ground with 2–5% of argillaceous material containing alumina, silica, and iron oxide, and calcined at 1425-1650 deg. until reduced to a dense sintered mass resistant to air and moisture.

U. S. P. 1,248,486/17 Handy. Impure dolomite is "dead-burned," molded into bricks with a temporary binder such as oil, tar or pitch, and reburned until a non-slaking material resisting hot water is obtained. The product is suitable for lining basic open-hearth furnaces.

B. P. 111,853/17 Kennedy. A refractory material for furnace linings, etc., is made by clinkering, at a higher heat than is used for cement, an intimate mixture containing 78–92 parts of lime and magnesia (from magnesia limestone or dolomite), 2–13 parts of silica and alumina or iron oxide or both. To a certain extent alumina and ferric oxide may be replaced by silica or in their place basic slag, blast furnace slag, bauxite, chrome iron ore, etc., may be used.

B. P. 113,199/17 Rollason. Bricks, blocks, etc., are made by roasting dolomite at 1050–1350 deg. until it becomes semi-fused, hard, granular and non-absorbent, crushing, and mixing with about 1–5% of finely crushed dry silica or siliceous clay. The thoroughly mixed mass is damped with water or other liquid, or is mixed with hot dry tar, molded, and heated in a kiln to the fusion point of the silica or clay. The temperature is then raised slightly above that of fusion, then lowered below the fusion point, and finally raised and maintained at the highest heat attainable in the kiln.

B. P. 119,101/17 Mason. In making refractory magnesite bricks, borates or perborates with one or more fluxing agents, as, basic slag, iron oxide, iron ore, metallic iron or iron slag, are mixed with calcined or raw magnesite and water,

formed into bricks and fired. Alternatively the fluxing agent and borate, etc., are mixed, shaped into bricks, calcined, and powdered before mixing with the calcined magnesite. In 100 parts of the mixture are about 1 part of borate, etc., and 6 parts of the fluxing material.

Can. P. 176,727/17 Wagner. A composition for making fire-brick contains coal ash 100 lbs., magnesia 3 lbs. and water 2 gals.

Swiss P. 73,100/17 Magnesitwerke. Strong binding magnesium oxide is made by burning dolomite and other magnesian rocks (collecting the carbon dioxide), adding water to the product and introducing carbon dioxide, under pressure to form soluble magnesium bicarbonate which is filtered off and boiled, forming the normal carbonate. This is dried and burned, then moistened, pressed, again burned, and ground.

U. S. P. 1,251,535/18 Jones. Granulated dolomite is formed into a paste with furnace flue dust and the mixture is heated to calcine the dolomite and cause adhesion of the flue dust. The product is used as a substitute for magnesia furnace linings.

U. S. P. 1,265,345/18 Stowe. Refractory material for lining metallurgical furnaces is formed by molding the article from magnesite and water, coating it with pulverized iron oxide and burning at a temperature which drives off water and carbonic acid and effects a union of some of the iron oxide with the magnesia at the surface.

U. S. P. 1,270,818/18 Handy. A refractory material for lining open hearth furnaces is formed by moistening granulated dolomite with a solution of calcium chloride, drying and calcining at á high heat to leave less than 1% of chlorine. Granules of this material are made into bricks resisting the action of air, steam and water.

U. S. P. 1,270,819/18 Handy tells of making a refractory material by calcining dolomite, extracting with cold water to remove most of the lime (leaving 3-10%), and reheating with a little bonding material such as silica or iron oxide.

B. P. 129,485/18 Brooke. A small amount of fine flue dust from the downcomers of blast furnaces, containing a high % of magnetic oxide of iron is added to the material used in making acid or basic refractory bricks or blocks, e.g., for making magnesite bricks, 2.5–10% of flue dust is added and for making silica bricks, 0.5–3%, the amount of lime added being less than that ordinarily used.

B. P. 133,753/18 Pike. Magnesite is mixed with a small quantity of a deoxidizer in the form of an iron alloy, such as iron-manganese, or iron-silicon, and then heated to cause a reaction reducing the total quantity of oxygen associated with the iron and more or less liberating the metallic iron.

U. S. P. 1,300,631/19 Meyer. Granular refractory material suitable for lining furnaces is produced by feeding granulated dolomite down through an inclined rotary kiln against flame and flame gases in mixture with 9–12% of basic open-hearth slag granules. The dolomite granules may be about 0.19 in. in diameter and the slag is preferably ground to pass a 50-mesh sieve.

U. S. P. 1,307,197/19 Hanson. Magnesia 83 parts is mixed with a siliceous material such as fire-clay 17 parts and with a temporary binder such as water and sodium silicate and bricks formed of this mixture are heated to 1600 deg. to cause incipient slagging and produce a fire-brick, suitable for use in furnaces for fusing alkalies.

U. S. P. 1,324,546/19 Ferngren. A material suitable for furnace linings or crucibles is formed of zirconium oxide, calcined magnesia, and alumina in equal amounts, with a clay flux bond.

Can. P. 189,142/19 Pike. U. S. P. 1,312,871/19 Pike. A metallic deoxidizer such as a ferro alloy is mixed with magnesite and the mixture is heated to cause reaction.

If necessary, iron oxide may be added. When water is added the product may be molded into any desired shape.

Can. P. 192,126/19 Patnoe. A refractory material for furnace linings is made by adding 2 to 5% of argillaceous material in the form of silica, alumina, and iron oxide to magnesium limestone, grinding the mixture so substantially all will pass 100-mesh and calcining at 2600 to 3000 deg. F. until it is reduced to a dense sintered mass resistant to air and moisture.

U. S. P. 1,329,434/20 Sheard. A material suitable for lining furnaces is formed by burning dolomite, converting part of the lime in the product to calcium chloride by addition of an aqueous iron chloride solution and separating the resulting solid material, which may be mixed with a flux and molded.

U. S. P. 1,330,263/20 Handy. A basic refractory material suitable for lining furnaces is formed by pulverizing and mixing calcined magnesite 86%, iron oxide 8% and silica 6%, and calcining the mixture in a kiln to effect a union between the oxides of magnesium and iron.

MISCELLANEOUS REFRACTORIES OTHER THAN MAGNESIA

B. P. 6299/09 Berglund. Fireproof stone made by heating quartz to about 1500 deg. C., finely powdering and mixing it with 2 to 6% lime and 2 to 20% graphite, and treating the mass according to the usual methods for making lime sand brick.

G. P. 228,706/09 Lissauer. Fireproof and waterproof mass from kieselguhr, sodium tungstate and phosphate and dextrine and water glass.

G. P. 230,033/09 Tripmacher. In the manufacture of fire resisting bodies by binding together chrome ores with a binding agent containing organic substance, chromic acid is added to the binder.

U. S. P. 954,809/10 Jeppson. Making refractory linings, etc., by melting an aluminous material such as bauxite containing reducible oxides as of iron, silicon and titanium in an electric furnace under reducing conditions, crushing the product, and after removing ferrosilicon, subjecting it to an oxidizing roast, incorporating a bonding flux, as fire-clay, and forming the particles into a mass bonded by the reoxidized impurities and flux.

U. S. P. 961,651/10 Schlossberg. Making acid and fireproof bodies by soaking silica in water glass solution, impregnating the product with silico-fluoric acid, heating just sufficiently to drive off the silicon fluoride, and then to a higher temperature to drive off the sodium fluoride.

B. P. 1925/10 Seimens. In the manufacture of fire and acid proof molds, crucibles and the like, using phosphoric acid as the binding agent.

B. P. 18,820/11 Gutensohn. A fireproof compound is made from a powdered mixture of, preferably, fire-clay 3 parts, pipe-clay 1, and manganese dioxide with sodium silicate 0.05. Silica, sand, chrome ore, or other refractory substance may be added to withstand very high temperatures.

G. P. 294,796/11 Podszus. Thin-walled refractory products are made from the oxides of the rare earths of aluminum, silicon, magnesium, thorium, zirconium, and the like, without the use of clay. A thin slurry (containing a binder) is applied in layers to a refractory form coated with a filler such as gelatin, tragacanth, albumin, shellac, varnish, collodion, and the like.

U. S. P. 1,038,827/12 Becket. Refractory article of mixed titanium oxide and carbon, with an adherent facing of titanium carbide.

B. P. 29,389/12 Gen. Elec. Co. A refractory material is made by volatilizing by heat a mixture of silica 4 parts, carbon 2, and aluminum silicate, such as fire-clay, 4, with or without manganese dioxide 1 part, and condensing the product.

A soft, felty refractory material of low conductivity is produced, which may be employed for insulating electric furnaces, ovens, refrigerators, etc.

U. S. P. 1,062,771/13 Deidesheimer. Composition for clinkered paving blocks, formed of over 70% of differently sized fine granular refractory stony material, fluxing dust from the stony material and fire-clay.

B. P. 13,072/13 Burley. Fire-bricks or blocks for the construction of kilns, etc., are made from 4 parts by bulk of strong earth and 1 part of loam, with or without the addition of sandy earth chalk. The material is ground and tempered with a little water, is molded, and dried by sun, wind or force but not burned.

B. P. 28,326/13 Davy. Radiants for gas-fires are made by dipping a skeleton of metal wire, strips, or perforated sheets into a slip or thick fluid of refractory material consisting, for example, of clay, sawdust, burned clay, sand, emery, carborundum, steatite, or the like, with or without sodium silicate or pearl ash, the whole being mixed with water. The slip adheres to the skeleton, and the radiant is then baked.

G. P. 279,386/13 Schlossberg. Addition to 258,683. An acid-proof product, withstanding 800–1200 deg. C. is made from anhydrous silicic acid, water, lime and quartzite, with the addition of ground glass or powdered brick. Stones are made and hardened in the usual way.

G. P. 285,934/13 Knofler. The refractory vessels are made from the purest obtainable oxides of thorium and zirconium, and the rare earths, using only pure water as a binder and heating to about 2000 deg. C.

G. P. 287,554/13 Knofler. Addition to 285,934. Zirconia or thorium oxide or mixtures of both, or together with rare earths, without addition of foreign substances, are compressed and the product is finely ground and then stirred up with water, alcohol or the like, and poured into forms in the usual manner, dried, and burned. The vessels are claimed to be tight and strong enough to resist fracture when thrown upon a hard floor.

G. P. 287,779/13 Fredriksson. Fireproof vessels such as crucibles, are made from a paste containing water and powdered oxides of titanium, beryllium, zirconium, thorium or rare earths, together with a colloidal hydroxide of one of these metals and some free acid. Solid sol or a colloidal solution may be used. The proportions may be 1 part of solid sol and 100 parts of solid oxide, and the paste should contain about 0.1% of free acid. The cast or molding is dried and rapidly calcined to about 2100 deg.

U. S. P. 1,115,429/14 Hidecker. Fire-brick is formed of 75% of flint-clay or silica sand fusing at 1500 deg. C. or higher, 10% of plastic clay fusing at 1370 deg. 10% of shale fusing at 1230 deg. and 5% of refractory material such as carborundum which fuses only at 2200 deg. or higher.

U. S. P. 1,121,889/14 Arnold. Making refractory utensils by pressing a mixture of zirconium oxide and water in a mold into the desired shape and burning the molded article at a temperature of 1600–1800 deg. C. A glaze is formed of thorium and zirconium oxides mixed with variable amount of silica, titanium oxide, or alumina to regulate the fusing point. The utensils will stand a heat of 3000 deg. without fusing. Thorium oxide yields a similar product.

B. P. 289,992/14 Bauer. Ordinary refractory masses or vessels receive a surface coat of highly refractory rare earths, such as zirconia or thoria, preferably by the electro-osmotic method.

U. S. P. 1,152,428/15 Malm. Pyrometer tubes or combustion tubes and similar refractory articles are formed of fused alumina carrying a coating of glazing material to render them impervious to gases and with outer and inner coatings of fused alumina. The latter prevents the glazing from adhering to the support of the tubes when it is heated in use.

U. S. P. 1,156,018/15 Newberry. A basic refractory lining for lime or cement

kilns, etc., is formed of Portland cement clinker mixed with about 10–20% of calcium chloride which causes the clinker to form a firmly coherent lining. Other halides of the alkaline earth metals have similar effect.

U. S. P. 1,157,662/15 Arnold. Fireproof utensils are made from a paste of rare earth oxide, mixed with a small amount of free mineral acid and a dilute colloidal solution of hydroxide of the metal whose oxide is used. The mixture is molded and then calcined at 1600–2100 deg. C.

U. S. P. 1,159,264/15 Peaff. For making crucibles, furnace linings, etc., a homogeneous, dense and tough material is prepared by mixing zirconia with about an equal amount of somewhat coarser-grained carborundum; molding and burning.

B. P. 2,578/15 Sidebottom. A composition for lining crucibles consists of 112 parts of yellow sand and 8 parts of gas tar. It is placed in the crucible and baked for 5 hrs. at 200 deg. F.

B. P. 4,080/15 Just. A mixture of carborundum and zirconia which is molded and then burned is used as a refractory material for crucibles, furnace linings, building materials, or for electric resistances. Equal portions are satisfactory, but the proportions may vary.

U. S. P. 1,192,099/16 Nordin. For fire-brick, limestone and quartz are separately heated to 1500 deg. or higher, the lime and silica are reduced to a flour, formed into a brick-making paste with water, molded and tempered with steam under pressure. About 6% each of water and lime are used in the mixture.

U. S. P. 1,197,327/16 Allen. A mixture of silicon carbide 90 and clay 10 parts is incorporated with about 5 parts each of saturated solutions of ferric chloride and of sodium chloride, molded into bricks for furnace linings or into other refractory articles, and burned to decompose the ferric chloride and vitrify the resulting oxide of iron with the clay at the surface of the molded mass.

U. S. P. 1,198,033/16 Hershman. A refractory material for furnace linings is formed by firing alumina or aluminum dust with carbon (not enough to convert all the alumina into carbide) at a high heat (about 2200 deg.) to obtain a product which is nearly inert to hydrofluoric acid.

U. S. P. 1,204,211/16 Tone. Furnace lining bricks or other refractory articles are formed by mixing silicon carbide ranging in size from 14 to 150 mesh with not over 10% of an inert clay which vitrifies at 1500 deg. or higher, molding and firing above 1500 degrees C.

U. S. P. 1,209,784/16 Wagner. Fire-bricks are formed of a mixture of coal ashes 100 lbs., alumina 2 lbs. and water 2.5 gals.

U. S. P. 1,212,846/16 Taylor. Refractory material for furnace linings and for other purposes is formed of flint clay (calcined and purified by removal of iron compounds) mixed with 2 different kaolins, one being highly refractory and the other highly plastic. The mixture is molded and fired.

U. S. P. 1,212,847/16 Tayor. Raw flint clay intended for use in making refractory furnace linings or similar materials is calcined to render impurities such as iron compounds visible and they are then removed by hand.

B. P. 102,507/16 Lecesne. Artificial corundum is obtained by burning with compressed air a mixture of bauxite and anthracite or other fuel, so as to form and immediately burn aluminum carbide; after fusion the excess carbon is burned. The product is ground, mixed with hydrated bauxite, or a mixture of quartz, quicklime and water, molded, and baked to form refractory bricks, crucibles, grinding wheels, etc.

B. P. 103,953/16 Barrett. As a lining for coke ovens, etc., blocks are made of 70% of Leeds fire-clay, 10% of sandstone, and 20% of calcined fire-clay, a surface is polished, and they are kilned and treated with hot vapors of one or more alkali chlorides. The parts not required to be treated may be coated with a wash of barium sulphate.

B. P. 111,355/16 Reynolds. In making refractory bricks, etc., the working surfaces are subjected to an additional burning to produce incipient fusion. The bricks are separated for burning by highly refractory material such as chromite, plumbago, or ground coke and tar.

F. P. 480,491/16 Mineral Products Co. B. P. 17,447/15 Mineral Products Co. Refractory products resistant to corrosion are made of aluminum or aluminiferous material and fine carbon which are heated slowly to form a carbide, but not to the fusing point.

F. P. 481,230/16 Steurs. A refractory furnace lining is formed of a mixture of carborundum 35%, aloxite 25%, clay or kaolin 20%, chrome mineral 20% with a binder of potassium silicate 54%, sodium silicate 24% and resin, dissolved in alcohol, 22%.

G. P. 309,707/16 Desgraz. Crucibles, muffles, etc., are made by mixing ground calcined magnesite, ground zirconia, and the like, with a mixture of gypsum and iron oxides or iron filings; the mass is moistened, shaped, and heated to a high temperature, when the gypsum and iron react, sulphur trioxide being expelled, and the mass sinters.

U. S. P. 1,221,618/17 Sperr. A cement for gas retorts, furnaces, etc., is formed of fire-clay 25, silica 35, silica bats 35 and feldspar 5 parts, finely ground and mixed with water.

U. S. P. 1,226,750/17 Chappell. Refractory material for furnace linings, etc., is formed when a mixture of leached calcined alunite with about 25% its weight of fire-clay is molded and heated.

U. S. P. 1,227,999/17 Hershman. Refractory material for making furnace linings, etc., is made of a mixture of alumina 85 and carbon about 15 parts sintered to 1800–1900 deg. in a reducing atmosphere, and then mixed with additional carbon and a binder such as asphaltum, pressed into form and then heated to about 1950 deg. in a reducing atmosphere.

U. S. P. 1,231,684/17 Youngman. Bricks suitable for use in building furnaces or kilns are formed of calcined bauxite mixed with about 7% of magnesite and 1.5% of chromium ore, burned at about 1500 deg.

U. S. P. 1,244,275/17 Zell. A refractory composition for furnace linings, etc., is formed of "siliconite" 100, aluminum hydrate 5 and dehydrated gypsum 5 parts, together with sufficient 10% caustic potash solution to make the mass plastic but not to give an alkaline product. After molding and heating to 260 deg. for 5–6 hrs., the bricks may be used without further burning.

U. S. P. 1,244,688/17 Becket. Slag derived from the manufacture of high-carbon ferrochromium is used with 4–7% of a sodium silicate solution for making bricks for lining furnaces.

Can. P. 178,152/17 Martin. A lining for furnaces consists of brick clay 15, infusorial earth 8, soapstone 4, and asbestos 6 parts mixed with dilute salt solution.

Can. P. 180,678/17 Becket. Refractory compositions are made with ferrochromium furnace slag as an essential component.

U. S. P. 1,252,785/18 Cox. A mortar for fire-bricks is formed of shale 75, ground brick 25, sodium silicate 30 and asbestos 75 parts.

U. S. P. 1,266,478/18 Hutchins. Molded articles are formed of a mixture of silicon carbide, silicon and coal-tar pitch and are baked slowly in a neutral or reducing atmosphere to drive off the volatile matter from the binder and convert it into a carbon matrix in which the silicon carbide and silicon particles are embedded and held together. The articles are then heated in an atmosphere of silicon and silica vapors to a temperature sufficiently high to convert the carbon of the matrix into silicon carbide and produce a homogeneous mass having a continuous structure. Crucibles, rods, muffles, tubes, plates or dishes may be thus formed.

U. S. P. 1,273,529/18 Oliver. A refractory ceramic material suitable for pyrometer tubes or electric resistance or heating rods is made by mixing plastic clay 30, carborundum 70, water 5–10 and tar 5 parts. Graphite, fused alumina, magnesia, zirconia or bauxite may be used in similar mixtures for crucibles or muffles.

U. S. P. 1,275,354/18 Allen. A refractory material suitable for making crucibles, retorts or furnace linings is formed of fire-clay 48.5, anthracite coal 48.5 and galena 3%.

U. S. P. 1,277,227/18 Linbarger. A refractory material for making crucibles is formed of graphite in flake or granular form 43, silicon carbide 43 and clay 14%.

U. S. P. 1,289,049/18 Kraus. Bauxite or similar material is powdered, mixed with twice its volume of ground wood and molded into blocks with water and glucose or other binder, dried, and then roasted (preferably about 160 deg. below the melting point) to produce clinkered material in the form of spongy grains with the cleavage planes destroyed. Air is supplied during the heating to oxidize and remove impurities, and after clinkering the material is crushed to the degree of fineness desired for use. Most of the iron oxide in the bauxite is eliminated during the process.

U. S. P. 1,289,578/18 Tone. Crucibles are formed of a mixture of natural or artificial graphite 40, fused crystalline alumina 40 and plastic clay 20 parts.

U. S. P. 1,289,966/18 Tone. A mixture of graphite 40, zirconia 40 and plastic clay 20 parts is used for making crucibles, retorts, muffles or other refractory articles.

B. P. 122,388/18 Sankey. Refractory bricks are made of siliceous material such as flint, chert stone, silica rock, quartz, sand or stone rich in silica, by calcining and using two grades, the coarser in size 16 to 100 mesh, and the other to pass 250 mesh. These are mixed wet with fiber such as straw, chaff, peat, wool, hair or the like; molded, dried, and fired above 1500 deg.

B. P. 126,192/18 Carborundum Co. Refractory substances are formed of carborundum 43 parts, natural graphite in flake or granular form 43 parts, and a binding material such as clay 14 parts, ground with water to form a moldable mixture, shaped and fired.

B. P. 126,229/18 Kraus. In making refractory products, non-plastic ground material is mixed with considerable ground combustible material such as wood, with water or glucose, etc., for bonding. Molded blocks are dried and roasted to produce a clinker in the form of spongy grains.

B. P. 133,842/18 Sankey. Waste refractory articles, such as fire-bricks, tiles, saggers, retorts, or the refractory lining of furnaces, kilns, flues, or coke ovens, which have been calcined in manufacture or use, are ground and mixed with sodium silicate and water, molded or worked by hand to the required shapes and fired.

Swiss P. 78,925/18 Akt.-Ges. Hunziker. A highly refractory rock material is made from quartz 85–98% and lime 15–2%.

U. S. P. 1,303,993/19 Tone. A refractory material suitable for making crucibles is formed of graphite 40, sintered magnesia 40 and clay 20 parts.

U. S. P. 1,321,085/19 Booth. A material for use as a protective coating on electrodes for electric furnaces or other articles subjected to a high temperature is formed of crushed sharp-edged quartz 20–40, feldspar 15–40, natural silica sand 15 and a binder such as an aqueous solution of sodium silicate and sodium sulphate 25–30%.

B. P. 133,014/19 Carborundum Co. Bats, saggers, and like refractory articles are made of a mixture of fire-clay and carborundum grit, the major portion of which is coarser than 60 mesh and finer than 16, and constituting less than 60% of the mixture. Clay grog may also be added. For example, 40% each of crystalline carborundum and plastic sagger clay are mixed with 20% of clay grog obtained

by crushing old saggers or calcined flint, fire-clay, or the like. The articles are fired at about cone 11 (1370 deg.)

B. P. 137,419/19 McMinn. A mixture containing 30% or more of powdered glass, together with fire-clay such as Stourbridge or china clay, or a clay containing over 90% silica is used as a glazing-cement for lining retorts or furnaces. A mixture of china clay with silica clay and ground glass in equal proportions may be employed.

Can. P. 189,135/19 Olson. A refractory composition consists of finely divided infusorial earth, sodium sulphate, aluminum sulphate and lime.

Can. P. 189,191/19 Tone. A refractory containing fire-clay and less than 60% carborundum which is largely retained on a 60-mesh screen, is used for making saggers which have little or no deleterious influence on the ware brought into contact with them.

U. S. P. 1,327,448/20 Stowell. A refractory plastic material suitable for lining furnaces is formed by treating carborundum containing free silicon with a caustic alkali solution to generate hydrogen and, after the evolution of gas has ceased, stirring the mass until it assumes its original volume.

U. S. P. 1,344,461/20 Thomas. A material suitable for use in block form or direct application as a mortar in lining furnaces is prepared by mixing unburned raw quartzite 1000 with Portland cement 30–100 parts and a hardener such as calcium sulphate.

U. S. P. 1,345,632/20 Purdy and Beecher. A composition of matter for a light weight fire brick consisting of a burned mixture comprising clay material containing combustible matter, a highly refractory non-siliceous clay, a plastic clay, and a clay material which will give a coarse texture to the brick and adapt it to withstand expansion and contraction under heat changes.

U. S. P. 1,346,959/20 Hinckley. Process of making a refractory article comprising preparing a mixture containing fully shrunk, graded carbon particles in mutual contact, and a ceramic bonding material proportioned to fill the interstitial spaces, forming the article from said mixture, and firing the same to a temperature sufficient to develop the strength of the ceramic bond and to convert portions of the mixture into silicon carbid.

U. S. P. 1,356,211/20 Linbarger. A refractory article, the body of which contains silicon carbid and having a coating free from silicon carbid and comprising a refractory glaze with a fusion point exceeding 1350° C.

U. S. P. 1,356,939/20 Ohman. A non-recrystallized refractory material for heat-resisting articles, comprising substantially 68% of silicon carbid, 25% of crystalline graphite, and 7% of a carbonizing binder, and a salt.

U. S. P. 1,360,355/20 Bassett. A composition comprising approximately 100 parts by weight of magnesium limestone, 1-2 parts by weight of iron, 4-6 parts by weight of a compound of silicon, and from 2-10 parts by weight of an alkali metal compound.

U. S. P. 1,362,316/20 Hutchins. As a new highly refractory material consisting essentially of a burned mixture of zirconium compound, composed principally of the oxygen-containing compounds of zirconium, and an aluminous material.

U. S. P. 1,364,849/21 Anderson. The process of forming a ceramic article comprising the steps of mixing refractory or abrasive crystalline grains with plastic clay water and grease extruding the mass through a die and forming a shaped article and thereafter vitrifying the clay bond.

U. S. P. 1,365,077/21 Ashenhurst. A composition of matter composed of dry solids, and consisting of the finely ground double silicate of calcium and magnesium as produced from the waste of asbestos mills, and a water-soluble salt, said composition when combined with water being adapted in and of itself to form a cement which will adhere to highly heated surfaces.

Belgium P. 1,365,230/21 Denis. A porous refractory material consisting of a mixture of pure, rich refractory earth, poor earth, magnesia and sawdust, heated to a temperature sufficiently high to consume the sawdust and thereby render the product porous.

U. S. P. 1,372,016/21 Frohman. A refractory material consisting of a mixture of finely divided dry fire clay, siliceous material and a vegetable compound capable when mingled with water of forming a binder.

U. S. P. 1,373,854/21 Berry. A process of manufacturing refractory material consisting in first mixing the desired proportions of magnesite and bauxite in a raw condition, then mixing water with the same, then burning the resultant product at a temperature sufficient to drive off moisture and gas, next regrinding said calcined product and mixing with water, finally forming same into a suitable shape, and burning such shape to produce a hard refractory article.

U. S. P. 1,374,538/21 Willetts. A composition of matter to be burned for the production of refractory heat-insulating material, containing finely divided carbonaceous material intimately mixed with plastic fire-clay having a high silicon content, the greater part of the silicon being combined in free silica, and the latter forming about 55% of the clay by weight.

U. S. P. 1,375,077/21 Buckman and Pritchard. A method of producing a refractory article which comprises comminuting zircon into particles the majority of which are in size not less than 90 mesh and other particles not greater than 200 mesh; mixing together said particles of different sizes; adding to the mixture a moisture impartive vehicle in quantity such as to render the mass plastic; shaping the mass; and subjecting it to temperature below the melting point thereof but sufficient to stiffen, or heat-compact it.

U. S. P. 1,376,091/21 Hartmann. A refractory article containing mainly carborundum and a bonding material containing mixtures of naturally occurring zirconium and aluminum silicates, said bonding material possessing a long and high vitrification range.

U. S. P. 1,380,700/21 Breerwood. The process of making refractory substances adapted for use in making refractory linings or walls of open-hearth or similar furnaces, which consists in mixing with a lime substance a material adapted under heat to sinter with the free lime of the lime substance, grinding the two together until their constituents are thoroughly intermingled in a fine state of division, mixing with it small pieces of material to which the finely divided substance is adapted to adhere in its passage through the furnace, introducing such a mixture into a furnace, passing it through the furnace and subjecting it to intense heat therein during its passage therethrough, whereby the mixture will early in its passage through the furnace be formed into balls and be subjected to the intense heat while in such form during the greater part of its passage through the furnace to vitrify or fuse or amalgamate the mixture.

U. S. P. 1,380,701/21 Breerwood. The process of making dolomite bricks which consists in placing vitrified dolomite containing a small amount of iron, ground exceedingly fine, in a mold, compressing said material from both ends under high pressure to form a compressed brick at a sufficiently high temperature to amalgamate or vitrify it.

U. S. P. 1,390,327/21 Bassett. An acid proof refractory composition comprising approximately from 100-120 parts by weight of sand, about 5 parts by weight of iron oxid, about 4 parts by weight of sodium silicate, and about 5 parts by weight of Portland cement.

U. S. P. 1,390,328/1 Bassett. A basic refractory brick comprising double burned dolomite, a plurality of binding agents effective throughout different ranges of temperature from ordinary atmospheric temperatures to 3000° F. and approximately from 25-35% by weight of crushed brick made from the same composition.

U. S. P. 1,394,442/21 Purdy, Beecher, and Klein. A bonded article comprising magnesia, alumina and flux impurities, granular crystalline material of one of the oxids being bonded by said flux and spinel formed *in situ* from a portion of the oxids chemically combined under the action of heat below the melting point of the compound.

U. S. P. 1,400,087/21 Newberry. Basic refractory brick composed of calcined clinker of lime and argillaceous matter of a lime-argillaceous ratio of 2.30-3.00, crushed and freed from dust by sifting, with the addition of a mixture of lime and argillaceous matter of a lime-argillaceous ratio below that of the clinker, molded into blocks and burned at 2700°-3000° F.

U. S. P. 1,411,842/22 Collins. A refractory bonding and glazing composition comprising 40 parts fire-clay, 8 parts Portland cement and 1/64-1/32 part of copper sulfide.

CHAPTER II

CALCAREOUS CEMENTS AND ARTIFICIAL STONES

MORTAR, CEMENT, CONCRETE AND PLASTER

Some of the plastic materials in use today are products of the most modern scientific developments, and could not have been dreamed of two hundred years ago. This is true particularly of synthetic rubber and such products as described in the various classifications in a later portion of this book.

Others, as we have already seen, date from remote antiquity and even from prehistoric times. To this latter class belongs the lime mortar still commonly employed to-day in bricklaying, though it has been partly displaced in this use by cement or at least by mixtures of lime and cement. The date of the invention of mortar is lost in the dawn of primitive civilization. How man first hit on the discovery that limestone can be burned to quicklime, and that the quicklime so obtained, if mixed with sand, makes a serviceable mortar for bonding brickwork or masonry together, of this we are left free to our fancy to form a mental picture—there is no information to give the lie to our conjectures. That he was guided wholly by accident, and that his methods were purely empirical, there can, of course, be no legitimate doubt whatever, though the chemistry of the burning and slaking of lime is of the most elementary. Limestone or chalk is calcium carbonate, the combination of the base lime, or calcium oxide, with the acidic carbon dioxide. Upon heating to about 700° or more in a kiln, these two substances are split apart according to the chemical equation

$$CaCO_3 = CaO + CO_2$$

The carbon dioxide, CO_2, escapes as a gas, leaving behind the quicklime, CaO. In the operation of slaking, which is the first step in the preparation of mortar, the quicklime unites with water

$$CaO + H_2O = Ca(OH)_2$$

forming calcium hydrate, the reaction being attended with considerable evolution of heat, so that the mass steams. It is customary to carry out the operation on a bed of sand which has been banked up to receive the quicklime. After the requisite quantity of water has been added (about 1½ gallons for every bushel of lime) the partially slaked lime is covered with sand and allowed to stand for some time to complete the reaction. It is then mixed with sand in proper proportion. This proportion will vary somewhat according to the nature of the lime and other circumstances. A common proportion for work above ground is about

one part of lime to two or three parts of sand; for use below ground somewhat less sand is recommended, say about equal parts of lime and sand. The mortar should preferably be allowed to stand for some time after mixing, otherwise slaking is apt to be incomplete and will continue after the mortar is in place. As water is consumed in the process of slaking, this tends to dry up the mortar, which consequently crumbles.

The sand employed may be river sand or pit sand. The latter has the advantage of being composed of sharp, angular grains, on which the lime has a better hold than on the rounded grains of river sand worn smooth by attrition. Sea sand is undesirable, partly because of its rounded grains, but more especially because of the sea salt adhering to it, which cannot be completely washed off even in careful washing. If pit sand is used, it must be washed to remove organic impurities, as these would weaken the mortar by their decay in the course of time. The sand is also screened to remove coarse particles and pebbles.

The Hardening of Sand-lime Mortar. The first set of mortar is simply due to the formation of solid crystalline hydrate of lime, as the water evaporates into the air. The sand undoubtedly assists in this process by rendering the mass more porous than a mortar made of lime alone would be. To what extent the sand enters into chemical reaction with the lime, with formation of a silicate, and thus takes part in the setting process, is a somewhat open question. It does not seem, however, that such action could play any dominant rôle, for it is well known that in deep masonry the mortar in the interior, which has been protected from access of air, sets with extreme slowness. So, for example, when some fortifications erected in 1666 were demolished by Treissart in 1822, the lime in the interior of the masonry was found to be quite soft, after a lapse of 156 years.

The principal cause of the permanent setting of mortar, however, is the formation of calcium carbonate by the absorption of carbon dioxide from the air:

$$CaO + CO_2 = CaCO_3$$

whereby the lime is practically reconverted into limestone from which it originated.

Addition of Other Substances to Mortar. In place of sand various other substances can be incorporated with slaked lime to make mortar. Ground burned clay or ground brick, for instance, have been used. Unlike sand, however, these materials containing alumina seem to enter into some kind of a reaction with the lime; at any rate the product has in greater or less degree the property of setting and hardening spontaneously, independent of the action of carbon dioxide. Such mortars are, in fact, more or less hydraulic, they will set even under water.

Hydraulic Mortars and Cements. The coast of Cornwall having for many years enjoyed an unenviable notoriety on account of the many shipwrecks of which it was the scene, the British Government in the year 1760 charged John Smeaton with the task of building the Eddystone Lighthouse, which should stand as a warning to navigators. He ac-

cordingly set out to investigate limestones of different origin as to their suitability for structures exposed to the action of sea water, which led to the discovery that certain limestones containing a considerable proportion of clay were peculiarly resistant to the action of water. To-day we speak of them as hydraulic limes.

A little later, in 1796, a certain James Parker took out a patent for another kind of hydraulic cement, which he obtained by burning nodules of impure limestone occurring in certain clay deposits. This came to be known as Roman cement, and is a typical example of the class of *natural cements,* as distinguished from those which are made by mixing various ingredients together. In our own country, in the early part of the last century, during the construction of canals in New York State, one of the contractors discovered that by calcining and pulverizing certain rock, a very useful hydraulic cement was made. A plant was established and great quantities of this cement were used in the construction of canals. This cement was given the name of "Rosendale," for the district of New York State in which it was first manufactured. In composition, the rock entering the "Rosendale" cement was a limestone carrying from ten to fifteen per cent of clay matter.

The temperature of calcination was carried only high enough to expel the carbon dioxide from the calcium and magnesium carbonates present in this rock. No attempt was made to fuse or vitrify the cement; indeed, if partial or complete vitrification resulted, the product was found to be inferior in quality. Somewhat later, rock of this kind was discovered around the Lehigh District of Pennsylvania, in Southern Indiana, in Illinois, and near Buffalo, N. Y. Thriving cement plants sprang up in these regions. The class name of "Natural" Cements was given to the products owing to the fact that they were manufactured from natural rock without addition of any kind. Their use grew to large proportions, until during the nineties several million barrels per year were manufactured.

But Smeaton and Parker and our own pioneers were far from being the first in the field. The aqueduct which supplied the ancient city of Rome was lined with a concrete made from crockery fragments and hydraulic cement. A detailed account of this aqueduct has come down to us by the hand of Frontinus, one time Curator of that structure, and a man of fine character and public spirit. Having been appointed to this position of trust by the Emperor Nerva he set to work to familiarize himself with every detail of the public utility placed under his care. In the opening paragraphs of his treatise he says: "I therefore consider it to be the first and foremost thing to be done, as has always been my fundamental principle, in other affairs, to learn thoroughly what it is I have undertaken." This system of aqueducts was a very remarkable structure. Clemens Herschel, to whom we owe a translation of the treatise of Frontinus, tells us that it comprised, in all, fourteen separate aqueducts carrying water from eighteen springs or rivers at a distance varying from seven to forty-four miles from Rome. Their aggregate length was 359 miles, of which 304 were below ground, and 55 were supported on arches. One

of the arches was 109 feet high. With pardonable pride, though perhaps not with altogether correct judgment, Frontinus comments: "Will anybody compare these wonderful works, serving so many needs of man, with the idle pyramids, or with those other useless, though much renowned works of the Greeks!"

The fact is that not only the Romans but the Greeks also knew how to make a hydraulic mortar by adding to slaked lime certain materials of volcanic origin.

In particular the so-called pozzolanas, or the lavas and tuffs found near the ancient Puteoli, the modern Pozzoli in the Bay of Naples, have the property of imparting hydraulic qualities to quicklime when added to it in finely ground condition. Thus they resemble burned clay or ground bricks and pottery in their action; this is perhaps not very surprising, for these products are essentially of the nature of clays which have been baked by volcanic heat and reduced to a fine sand by the action of steam. They are, as it were, a kind of natural ground brick. As a matter fact the use of artificial pozzolanas made by crushing broken bricks, tiles or pottery to a fine powder, was also known to the Romans. Indeed, hydraulic cements are so old that history does not trace their first use. Many of the ancient races made hydraulic cement by mixing together slaked lime and the materials now known as pozzolanas. Great care was exercised by the ancients in preparing these cements. They were usually mixed some months before use, and were kept in cool, moist vats, and at intervals were thoroughly beaten with wooden staves by the slaves. In the manufacture and use of these cements in ancient times, workmanship was of the highest character, as only tribes who were successful in warfare, became so opulent as to use cement; and since such tribes necessarily had plenty of slaves through the spoils of war, labor was a practically negligible cost. As a result, these people working with hydraulic cements produced results which we to-day are unable to duplicate. The explanation of this is probably to be found in the care in preparation, and in the skilled and thorough workmanship in the application of cements.

Natural pozzolanas at the present day are also obtained from Teneriffe, in the Canary Islands (this product is known as *tosca*, and is chiefly used in Spain); from Brohl, near Andernass, on the Rhine (so-called *trass*); and from the Greek Island of Santorin (*Santorin earth*).

Slag Cements. A strictly modern source of cements are the slags obtained in metallurgical operations. The basic slag obtained in the operation of blast furnaces for the manufacture of iron is granulated by running it hot into water. This not only reduces it to small particles but at the same time much of the sulphur in the slag is eliminated by the action of the steam, with which it forms hydrogen sulphide. The granulated slag is dried and ground, and is then ready for use as cement. According to the nature of the slag it gives rise to one or other of three different types of cement. The ground product may either be ready for use without further addition, thus resembling the natural

cements which we have already noted, or the ground slag may resemble the pozzolanas, and form a hydraulic cement when mixed with slaked lime. A third type of slag cement is prepared by calcining a suitable slag together with limestone.

A slag cement of rather different type is also made by mixing granulated slag with plaster of Paris. Searle states that such cements are peculiarly resistant to acids and magnesium salts.

Portland Cement. In 1824 Joseph Aspdin, an Englishman, took out a patent covering the manufacture of a cement by the calcination of a mixture of clay and limestone. He called the resulting product "Portland" cement, owing to a slight or fancied resemblance to the famous limestone quarried at Portland, England, and known to all English architects and contractors as "Portland Stone."

The work of Aspdin was of a rudimentary nature, and little attempt was made to closely control the proportions of clay and limestone. Other investigators, however, continued his work, and Portland cement developed with rapidity. In distinction to Natural cement, it was manufactured from a mixture of two materials, and was calcined at a sufficiently high temperature to bring about vitrification.

In earlier days, the raw materials were ground in the form of a sort of mud, molded into bricks, which were dried and burned in upright kilns, and these kilns were charged with alternate layers of the bricks of raw mix and coal. When drawn from the kiln, the product had to be carefully sorted, and was then ground to a more or less fine powder. Extensive research showed that best results were obtained when the finished cement contained from 20 to 23 per cent of silica, 5 to 8 per cent of alumina, 1 to 5 per cent of iron oxide, and from 60 to 64 per cent of lime. Chemical control was, therefore, installed in the Portland cement mills to analyze the raw materials, and so proportion them as to bring this composition into the product. Methods of burning underwent great development, and the rotary kiln utilizing powdered coal came into use, which resulted in great economy. Further refinements were made in the grinding machinery.

With its improvement, Portland cement was found to be superior in many ways to Natural cement, and, as the cost of production of Portland cement decreased and energetic competition grew up, the price fell gradually, until, through the combination of the low price and better quality, Portland cement made serious inroads on Natural cement, so that to-day the production of the Natural cement had fallen to an insignificant figure, while in 1917 there were produced in the United States 90,000,000 barrels of Portland cement.

A great variety of raw materials is used in the manufacture of Portland cement, the essential being that they contain silica, alumina, iron oxide, and lime in suitable proportions. A large share of the American production of Portland cement is made in the Lehigh Valley of Pennsylvania, from material called, "Cement Rock." This rock contains the above mentioned ingredients in such proportions that it is in many cases used without the addition of any other material. In other sections of the country, the combinations of clay and lime-

stone, shale and limestone, marl and clay, and marl and shale, are used. Within the past few years large quantities of Portland cement have been manufactured using blast furnace slag and limestone as the raw materials, along the lines indicated under the heading "Slag Cements."

Iron Ore Cement. It has been found that the place of alumina in Portland cement can be taken by oxide of iron. That is, in preparing the cement, instead of calcining a mixture of limestone and clay or shale, a mixture of limestone and iron ore may be used with good effect. Cement so made has been used extensively in the construction of the Panama Canal and for other marine work.

Retarders and Accelerators. Certain substances, when incorporated in the cement, exert a retarding influence upon its time of setting, while others accelerate it. Calcium sulphate (gypsum) is the substance most commonly employed when it is desired to retard the setting, a small quantity (2 to 3 per cent) being sufficient for the purpose. Searle recommends the use of plaster of Paris rather than gypsum, and also quotes the following list of substances, given by P. Rohland, as exerting a retarding influence: Potassium dichromate, boric acid, borax, sodium sulphate, potassium sulphate. The same author lists the following accelerators: Calcium chloride, aluminium chloride, potassium sulphide, sodium carbonate, aluminium sulphate and alum. Exposure to the atmosphere and to moisture (steam) also prolongs the time of setting of cement.

CEMENT CONCRETE

Ours has been called the age of concrete. For though the use of this material for structural work dates from antiquity the development of the art of its application had for many years lain in abeyance, to be resuscitated, as we have seen, by John Smeaton, Joseph Parker and John Aspdin, who furnished us with its fundamental constituent, hydraulic cement; and it has been reserved for comparatively recent years to demonstrate the extraordinary versatility of this material, its application to the most varied uses. Its excellence for massive marine structures, docks, dams, canals, bridges, reservoirs, sea-walls and the like, represents but one extreme of the range of its usefulness. At the other end we have fence and telegraph posts, paving stones, roofing tiles, electrical insulators, and a host of articles of moderate or small dimensions.

Concrete is an artificial stone composed of various "aggregates" bonded together with hydraulic cement. Since the chief function of the aggregate is merely to give body to the concrete while economizing the quantity of cement which would be required to fill the same space if neat cement were employed, it is readily seen that the requirements made of an aggregate are not very stringent, and can be satisfied by a variety of substances. They must, of course, have sufficient strength; they must not be too heavy; they must not be perishable, at least when protected by the enveloping cement; it is desirable, so

far as possible, that they should be resistant to heat, in case of fire; finally, it is desirable that they be presented in a form which affords a good grip to the cement used as bond. Their cost must, of course, fall within the limits prescribed by economy according to the exigencies of each particular case.

This enumeration of the requirements bars from consideration some of the heavier igneous rocks, although granite is used very effectively for large structures. Limestone makes excellent concrete, although it is not fireproof, since it burns to quicklime on exposure to fire. Hard coke makes a very good aggregate where light weight rather than great strength is required, and, contrary to what one might expect, concrete made from this material is fireproof. It also presents the special advantage that nails can be driven into it. Ordinarily, pebbles are too rounded and smooth to make an ideal aggregate, but this minor disadvantage is largely counterbalanced by the fact that they occur "ready made" in nature in the suitable range of sizes. Broken bricks and burned clay must be mentioned as some of the artificial aggregates.

Size of Particles. The size of particles of the aggregate depends to some extent on the use for which the concrete is employed. In large structures, boulders of considerable size may be imbedded while for most ordinary purposes, two and a half inches represents about the limit of the size of particles to be recommended. A general rule is that the particles should be of graded size, so that the spaces (voids) between the larger pieces will be filled up as much as possible by the smaller grains. This greatly adds to the strength of the concrete. The finest particles are usually introduced in the form of sand, which should be free from clay, and may have to be washed to insure this. Instead of or in addition to sand, ground pozzolanic material may also be included. This has a beneficial effect upon the concrete, since the pozzolana here exerts an action similar to that by which it converts ordinary slaked lime into a hydraulic cement.

Waterproofing Concrete. A thoroughly well made concrete, in which the aggregate is carefully graded, so as to fill the voids as much as possible, is in itself in high degree waterproof. Where resistance to water is essential, as in submerged structures or water cisterns, for example, it is therefore important that special attention be paid to the proper composition and laying down of the concrete.

There are, however, several methods available for adding to the natural waterproof qualities of a concrete, or for imparting some degree of such qualities where they would otherwise be deficient. The methods that present themselves may be divided into three classes, namely those depending on

1. Surface treatment.
2. Incorporation of various substances in the body of the concrete.
3. Insertion of impervious layers of fabric or the like at suitable points in the concrete structure.

1. Surface Treatment. The surface of the concrete may be treated, with more or less success, with various damp-proofing compositions. Alternate applications of soap and alum cause the formation, in the pores of the concrete, of an insoluble and water-repellent alum soap. The results are not very satisfactory. Heating the concrete surface and applying melted paraffin is a more effective, but a rather costly method. A variety of compounds of greater or less merit for waterproofing the surface of concrete has been placed upon the market under trade names, the majority of such compositions containing silicates or fluosilicates of soda, aluminium, magnesium or zinc. Sodium oxalate, which forms the highly insoluble calcium oxalate by double decomposition with the free lime in the concrete, has also been used.

Instead of treating the surface of the concrete in the endeavor to render it waterproof, an impervious coat of cement may be applied to it, after giving it a thorough cleansing. Painting with asphalt or pitch is a good method to apply to unexposed surfaces, such as the interior of walls.

2. Incorporation of Water-Repellent Ingredients in the Concrete Mix. Various powdered and liquid materials have been put forward for rendering concrete impervious, by incorporating them with the mix from which the concrete is made. Powders are, in general, unsatisfactory, as it is practically impossible to insure their uniform distribution through the material. Liquids are better adapted, in this respect, but the addition of oils, which is sometimes recommended, has in some cases been found to reduce the strength of concrete by one half.

3. Insertion of Impervious Layers into Concrete Structures. A good example of this method of waterproofing is seen in the construction of the New York subway, as described by J. Rosenzweig. At the stations brick and asphalt are used for the roof and three-ply membrane waterproofing for the side walls. Between stations only the roofs are waterproofed, usually with three-ply fabric. In ground water the structure is usually waterproofed with brick in mastic below a line two or three feet above the water level. Where space is limited, six-ply membrane is sometimes substituted for brick in mastic.

Membrane Waterproofing. The fabric employed is a jute burlap saturated and coated with pitch or asphalt, which comes in lengths of 100 to 150 yards wound on wooden cores. It is strong and pliable at nearly all temperatures; only in very cold weather it may become brittle and chip.

The pitch employed in laying the membrane is coal tar pitch heated to between 225 and 275 degrees F. It is important that the temperature be carefully regulated, since the pitch is liable to coke and become worthless if overheated. In freezing weather, or as soon as the temperature falls below 34 degrees F. operations must be interrupted, as the pitch will not stick to cold concrete. In warm weather, on the other hand, precautions must be taken to prevent the membrane from sliding down where applied to vertical or inclined structures.

Before laying the fabric in place the surface which is to receive it

must be made smooth and clean. It should be dry, or, failing this, should receive a preliminary cover of felt. The surface of the concrete or of the felt cover is then mopped with hot pitch and the first ply of fabric is then immediately applied, tightly stretched, smoothed, and pressed down on the pitch. Successive layers are similarly applied, the lap joints being in each case carefully mopped. The lap joints should be so directed that any water which should by any chance gain access to the membrane would run down over the joints, and not into them. After the top ply is laid down it should be mopped over thoroughly with pitch. As soon as possible after the top layer of pitch has cooled a protective layer of concrete from three to six inches in thickness is applied.

Brick-in-Mastic Waterproofing. This consists of a layer of carefully dried bricks laid down in a mastic composed of asphalt, sand, cement or limestone dust, and, in some cases, asbestos fiber. The work must be so conducted that the individual bricks are nowhere in direct contact, but are always separated by a thickness of mastic. Since asphalt mastic shrinks in cooling, no concrete must be placed on top of a mastic wall until it has completely cooled and settled.

Shaping Concrete. Several methods are available for forming the plastic concrete into the shapes in which it is to function after setting solid.

In building construction the most usual procedure is to prepare wooden forms into which the concrete is dumped or poured either in the form of a fairly stiff mass, which is tamped into place to fill up voids, or as a thinner paste, which may require no tamping.

The preparation of the forms is a matter which requires nice judgment, as they figure prominently among the items of cost of concrete construction, contributing often one third or even more to the total. The boards used in making the forms can be used over and over, so long as they have the requisite length. It is, therefore, essential to avoid, as far as possible, cutting them down in putting up a new set of forms.

Another method sometimes applicable in placing concrete especially where it is used as a filling-in material, as in tunnel construction, is to squirt or pump it into place in the form of a thin paste, known as *grout*. Or, again, the concrete may be made into individual building stones, which are then laid like any other building stone. This method certainly possesses the advantage of avoiding the necessity of making new forms for each job, all the blocks being made of standard dimensions in a permanent mold. There is, therefore, some sound basis for the claim which has been made, that such concrete blocks make a cheaper construction than concrete placed in forms on the site.

Permanent molds are, of course, also used in making that large variety of molded articles, which is characteristic of the modern development of the concrete industry, from flagstones and roofing tiles to fence and telegraph posts. In many of these cases the concrete is reinforced, as also in building construction, by suitably dimensioned steel members embedded therein. Reinforced concrete is usually made

with a somewhat more fluid mixture than plain concrete mass, in order that the material may flow well around the reinforcing members and into all spaces between them.

Sand-lime Brick. In dealing with refractory materials of the ceramic class we had occasion to note that refractory bricks are made from a mixture of sand and lime heated to a high temperature. Such a mixture does not set solid at ordinary temperatures, but can be consolidated by the action of high pressure steam. The product is thus as it were an intermediate link between the fire-hardened ceramic wares and the cements and concretes of calcareous base, which set spontaneously at ordinary temperatures.

The sand-lime bricks consolidated by steam are not themselves suitable for refractory use, but can be made so by firing them, as has been noted on a previous page.

CALCIUM SULPHATE CEMENTS

1. Plaster of Paris. The mineral known as gypsum or selenite is a hydrated calcium sulphate, of the composition $CaSO_4 . 2H_2O$. When this is heated to about 107° C. it parts with a portion of its water of crystallization, and is converted into $2CaSO_4 . H_2O$.

The latter substance, when made into a paste with water, is reconverted into the original hydrate $CaSO_4 . 2H_2O$, which crystallizes and sets to a solid mass. The setting is accompanied by an increase in volume, a circumstance of which advantage is taken in making "plaster cast." The expansion of the plaster causes such casts to reproduce faithfully and sharply the lines of the mold in which they have been prepared.

On a manufacturing scale plaster of Paris is made by carefully heating gypsum in kettles provided with stirrers or in revolving drums. The temperature has to be carefully controlled, and local overheating avoided by keeping the material constantly stirred; for at a temperature not greatly in excess of that required for making the plaster of Paris a further loss of water occurs and the gypsum is then "dead burned," that is to say, it is converted into anhydrous calcium sulphate, $CaSO_4$, which does not set with water in the same way as plaster of Paris.

The preparation of plaster from gypsum is another instance of a very old art, for it was practiced among the ancient Egyptians.

2. Keene's Cement. Although in the manufacture of the quick-setting plaster of Paris a moderate temperature is essential, cements of a somewhat different character are obtained by calcining the gypsum at a dull red heat (500° C.). So called flooring plaster is produced in this manner. A closely similar material is that known as Keene's cement, which is prepared by first converting gypsum into plaster of Paris, then moistening this with a small quantity of a solution of alum or aluminium sulphate, and reburning at about 500° C.

Keene's cement and other cements made by calcining gypsum at a high temperature take several hours to set.

3. Dental Compositions. The modern dentist has quite a variety of plastic materials to select from in filling teeth. In giving a brief survey of some of the principal dental compositions it is well to include metallic substances, since these cannot very well, in this art, be separated from non-metallic cements and inlays.

The materials used for filling teeth may, for our present purpose, be divided into the following classes:

1. Metals and Alloys, in solid form.
2. Amalgams, that is to say, soft pasty alloys of other metals with mercury.
3. Non-metallic cements and inlays.

1. Solid Metals. It seems at first sight rather surprising that it should be possible to fill a cavity in a tooth with solid gold by pressing and hammering the metal into shape on the spot. Plasticity, in this case, is secured in a rather unique way, namely by using the metal in form of a very thin foil, which can be compacted in the same sort of way as that by which children roll tin foil into a ball. In the ball of tin foil, however, there is no actual union between the pieces of foil thus pressed together; the gold foil of a dentist's filling, on the contrary, may be actually welded together into a thoroughly compact mass. This property of welding in the cold is peculiar to perfectly clean, fresh gold foil, and is apt to be lost when the foil is exposed for some time to the air. In such case it can, however, be restored, by simply warming the material. But the gold foil is also used sometimes in the non-cohesive form. Gold is also used, for filling teeth, as an alloy with platinum, or with tin.

2. Amalgams. Mercury dissolves practically all metals, and the resulting alloys are spoken of as amalgams. These, when freshly prepared in the right proportions, are soft and plastic, and have the property of setting hard within a short time after mixing. On this depends their use for filling teeth. Dentist's amalgams are commonly made from alloys of several metals, of the composition of which the reader will obtain an idea by consulting the table, on opposite page, reproduced from Dr. Black's *Operative Dentistry.*

DENTAL CEMENTS

1. Zinc Oxychloride. When zinc oxide is moistened with a solution of zinc chloride, it sets, on standing, to a hard mass which has found application in dentistry as a tooth filling. The cement may be colored to match the natural teeth by the addition of titanium oxide, ammonium calcium phosphate, cadmium oxide, etc. Ground glass is also commonly added to improve the wearing qualities, and there may also be introduced silica or the oxide of aluminum, magnesium or tin. This material is not adapted for fillings coming in contact with the saliva but must be covered with gold or other suitable filling.

2. Zinc Oxyphosphate. Zinc oxide, together with dry ingredients, similar to those of the preceding cement, is moistened with a syrup

Name of Alloy	*Silver*	*Tin*	*Copper*	*Zinc*	*Gold*	*Platinum*
Ash & Sons	66.54	27.16	5.02	0.9		
Davis	42.41	51.42	3.21		3.2	
Fellowship	67.71	27.95	3.18	1.16		
Flagg's Contour Alloy	58.00	37.00			5.0	
Flagg's Submarine Alloy	60.00	35.00	5.00			
Flagg's Facing Alloy	37.00	35.00		3.00	5.0	
Fletcher's	43.35	50.35	1.65		3.35	1.30
Globe	44.89	51.90		0.50	2.71	
Justi's Superior	35.20	69.10	3.50	1.80	0.32	0.80
Lawrence's	44.06	50.43	5.51			
Standard Dental Alloy (Eckfeldt)	52.00	40.60	3.00		4.40	
True Dental Alloy	65.91	27.13	5.21	1.52		
Twentieth Century	67.03	27.13	4.87	1.10		
Welch's	46.00	51.90			1.70	0.40

of phosphoric acid. It is less soluble in the saliva than the oxychloride cement and has also better wearing qualities.

3. Zinc Oxysulphate. This is prepared from a mixture of 3 parts of zinc oxide and one part of calcined zinc sulphate moistened with a solution of gum arabic containing a trace of calcium sulphate. This material is not adapted for fillings exposed to the fluids of the mouth.

4. Copper Oxyphosphate. This is made from copper oxide, to which silica has been added, and a syrup of phosphoric acid. This cement sets rapidly, has relatively good wearing qualities and resists the saliva better than any of the cements previously mentioned.

5. Silicate Cements. The dry constituent of this cement may be a mixture of basic beryllium nitrate, Be(NO), 2BeO, and sodium silicate; or it may consist of silicates of lime, alumina, and other bases, together with aluminates. This is moistened with a liquid containing orthophosphoric acid and an almost saturated solution of aluminium phosphate containing a trace of zinc or strontium phosphate.

The silicate cements offer quite exceptional and almost ideal opportunities for exact color matching, owing to the wide range of colors in which they can be obtained. They may be reckoned among the greatest assets of modern dental art.

PATENT REFERENCES

GYPSUM, PLASTER OF PARIS, STUCCO AND SIMILAR COMPOSITIONS

B. P. 20,169/08 Lane. Hearthstone. Powdered stone 1 part, gypsum 1, chalk 1.

U. S. P. 933,221/09 Young. Composite shingle. Two layers of paper felt are cemented together with stucco 60%, wood pulp 38.5%, hair 0.5%, graphite 1% and coated externally with silica 33.8%, alumina 22.32%, calcium oxide 6%, oxide of iron 4%, potash 1.6%, powdered coal 31.72%, water 100 parts.

U. S. P. 937,869/09 Rowe & Howard. Plaster board, boxes, etc. Calcined plaster 75, intermeshed twine, shredded corn cobs 20, alum 2.5, glue 2.5.

G. P. 226,076/09 Seidenstricker. In the manufacture of gypsum, adding small amounts of lime, trass, or barium carbonate.

U. S. P. 949,061/10 Grandall. Composition for Filling Cracks. Water 94 parts, salt 5 parts, oil of sassafras 1, glycerol 0.25, plaster of Paris 80, dextrine 13, white lead 7.

U. S. P. 950,355/10 Smith. Stereotype Molds. Clay, finely divided asbestos fibre, or pumice and plaster of Paris mixed with water.

U. S. P. 955,953/10 Ellis. Plaster Composition. Calcium hydroxide 7, sand 15, fibrous material, e.g., hair 1 and wood fibre 2 and calcined "lime sulphate borax waste" 10 parts. There may be added asbestos, serpentine, asbestine, talc. clay, zinc oxide, ferric oxide, and various coloring matters.

U. S. P. 957,144/10 Bye. Plaster board formed of a layer of plaster of Paris, open mesh burlap applied thereto while the plaster of Paris is still plastic, a layer of loose cocoanut fibres applied to and meshing with the burlap and a second layer of plaster of Paris impregnating the fibres.

U. S. P. 965,894/10 Hardin. Composition for making drainage tile, consisting of crushed rock 1.25, burned gumbo 1.25, soft coal cinders 1, cut straw 0.5, burned gypsum 1.

B. P. 6,384/10 Sundell. Manufacturing artificial stone from a mixture of modelling plaster 75 parts, powdered marble 50 parts, glue, gum or the like and a thin solution of alum.

B. P. 22,202/10 Holl. A cement consisting of a mixture of leather scrap, plaster of Paris, powdered or ground gum, glue, or the like, and powdered glass or the like, the mixture being worked into a paste by addition of a suitable liquid adhesive or water.

G. P. 229,698/10 Mundt. In the preparation of gypsum by means of water or steam, the gypsum heated in steam or water, and then dried, is sprinkled while hot with lime water, boric acid solution and alum solution, the moisture is driven off, and the product is ground.

G. P. 237,802/10 Mundt. Improving molded gypsum objects by employing finely pulverized or coarsely ground gypsum, and wetting it with solutions of glue, borax or alum and heating.

U. S. P. 984,518/11 Anderson. Roofing, comprising plaster 80 lbs., hair ¼ lb., water, enough to make stiff mortar, coal tar 2 pints.

U. S. P. 985,656/11 Cady. Making cement plaster. Adding to calcined gypsum, 2% of a mixture of caustic potash solution 1, aluminum sulphate 3.5 parts.

U. S. P. 999,474/11 Voglesong. Making plaster board by placing a mixture of plaster of Paris, cement, wood fibre and water upon the former of a pressure chamber, admitting additional water into the chamber before the solids have settled, and then admitting air under pressure to the chamber to deposit the solid matter upon the former and press the water out therethrough.

U. S. P. 1,000,295/11 Rumel. Composition for insulating steam pipes, etc., consisting of "lime putty" 65%, sawdust 30%, plastering hair 5%.

U. S. P. 1,006,725/11 Cramer. Dry storable mortar or plaster comprising a mixture of inert and mortar-forming material and sufficient magnesia to absorb the moisture present, so as to prevent deterioration in storage and transport.

B. P. 7,325/11 Zierow. Manufacturing a plastic substance by mixing crystallized powdered gypsum or Iceland spar and magnesia used with water, then adding this mixture to an aqueous solution of gelatin, and finally adding glycerol and wax or a waxlike substance with or without pigments, while heating.

Ger. 277,354/11 Bacigalupi. A matrix composition consists of a mixture of talc, limestone, witherite, powdered slate, powdered manganiferous iron ore, and gypsum, stirred up with water to a plastic mass.

B. P. 10,424/12 Keen. A plaster for internal use on walls is made of gypsum 34, chalk 31, water mud or clay 5, sand or ground flint 40, adding to every ton of mixture one-quarter pound of sodium silicate or potash alum, 2 ozs. of sulphur, 1½ lbs. molasses, ½ pt. glycerol, ½ gill acetic acid, concentrated essence of lemon or cream of tartar, ½ lb. zinc or copper sulphate, and 1 lb. gum arabic.

U. S. P. 1,051,857/13 Bertram. Making a wall coating by mixing sugar and lime, wetting the mixture, drying, and grinding it and mixing with plaster of Paris prior to final incorporation with water.

U. S. P. 1,076,261/13. Armstrong "Compo-board" made of gypsum 75%, sodium silicate 2.5%, borax 2.5%, and sawdust 20%.

U. S. P. 1,079,077/13 Turner. Making artificial marble by molding double-burned gypsum cement, treating the surface with a saturated solution of potassium sulphate and exposing to the action of the air for several days.

U. S. P. 1,081,565/13 Baker. Wall plaster formed of a quick-drying mixture of ground gypsum, sand and water mixed with comminuted leather which retains sufficient moisture to retard the drying of the plaster.

B. P. 639/13 Brothers. Plaster of Paris is prepared by heating gypsum or other hydrated calcium sulphate under reduced pressure.

B. P. 7,907/13 Denny. A mixture for flooring and like purposes consists of calcined gypsum, sawdust, wood pulp, seed husk or the like, glue solution, chrome alum, and formaldehydes or the like for rendering the glue waterproof, and with or without a glue preservative, such as creosote, precipitated silica, and linseed oil, and containing 2–3% sulphur. Drying oils or varnishes may be used in place of the linseed oil and sulphur.

G. P. 285,534/13 Renner. A mass that is suitable for stereotyping and may be worked with the etching needle, consists of a mixture, to be stirred up with water, of alabaster gypsum 2, whiting 2, zinc white 1, cement 1, flour 1, and glue 1 part.

U. S. P. 1,106,777/14 Campbell. Retarding the setting of calcined gypsum by the use of lime waste from the liming of hides, containing dissolved hair.

U. S. P. 1,106,778/14 Campbell. Making a retarder for use in gypsum plaster by heating lime waste (from liming hides) to convert the insoluble animal matter into soluble form.

U. S. P. 1,086,235/14 Stahl. Plastic mixture for forming "artificial wood" made by mixing water 5 qts., powdered rosin 12 lbs., molasses 5 qts., crude petroleum 3 qts., asphaltum 14 lbs., and plaster of Paris 15 lbs.

U. S. P. 1,099,961/14 Barton. Plastic mixture for making porous receptacles for vaporizing disinfectants, perfumes, etc., formed of plaster of Paris 32, dextrin 1, and ocher 7 parts.

B. P. 10,130/14 Brothers. A plaster is made by mixing together hydrated gypsum and dehydrated lime, and heating the mixture preferably to 212–300 degrees F. to dehydrate the gypsum and slake the lime.

B. P. 14,690/14 Finger. Fireproof wall plates or slabs composed of gypsum

and peat refuse are strengthened by a wooden framework consisting of longitudinal box-shaped bars, the cross-bars being connected by cords.

B. P. 16,560/14 Denny. A cement consists of a mixture of anhydrous gypsum and from 2 to 10% of crystallized ferrous sulphate (or equivalent anhydrous salt), with or without 1-4% of slaked lime or Portland cement, and filling materials such as sawdust, coke breeze, etc. The product may be used as a flooring for ships' decks.

B. P. 21,987/14 Denny. A quickly setting cement having an alkaline reaction is produced by mixing substantially anhydrous gypsum with 1 to 10% of Portland cement.

U. S. P. 1,127,514/15 Ramsey. A hard-setting finish for plastered surfaces is formed of slaked lime 74, gypsum 25, tartaric acid 1 part, with sufficient water to form a plastic material of the desired consistency.

U. S. P. 1,152,964/15 Nielsen. Dental models are made using a negative impression of plaster of Paris 4 and potato flour 1 part, molding the positive of plaster of Paris, and detaching the positive and negative from each other by immersion in hot water.

U. S. P. 1,166,325/15 Church. Uncalcined pulverized gypsum is mixed with about 1.5 times its weight of whiting or other inert powder and about 10% of its weight of glue to form a water-miscible composition for coating walls.

B. P. 4,289/15 Ford. In connection with the process of B. P. 3,030/15 in which alabaster or gypsum, in granular form is mixed with a binding-agent, celluloid dissolved in acetone is employed as a binder. The product is molded into slabs for wall covering, light reflectors or bowls, columns, cornices, etc. The molded articles may be turned and polished.

U. S. P. 1,170,038/16 Beebe. In making artificial stone a dry mixture is formed of crushed pumice 1.5, gypsum 1.5 and Portland cement 1 part and each cubic foot of this is mixed with 10 gallons of 1% sal ammoniac solution.

U. S. P. 1,184,184/16 Krieger. Kieselguhr is calcined above a red heat to increase its strength and then molded with water and about 30% of plaster of Paris as a binder. It is used for building blocks.

U. S. P. 1,185,773/16 Conwell. A plaster containing a large amount of slaked lime is mixed with 10–30% of natural cement with which about 5–15% of sodium pyrosulphate or other supersulfate has been previously ground. The latter serves to promote the setting and hardening of the plaster. U. S. P. 1,185,774 specifies the use of a fused cementitious material high in calcium aluminate, instead of natural cement in an otherwise similar composition.

U. S. P. 1,185,775/16 Conwell. Composition for accelerating the strengthening of plaster. A fused product containing calcium aluminate and about 7–20% silica is ground with 5–15% of an alkali metal persulfate and about 12–20% of the mixture is added to hydrated lime plaster to accelerate its setting and strengthening. The plasticity of the plaster is also increased.

U. S. P. 1,190,756/16 Haire. A stiff jelly-like mixture of animal glue with about 1.25 times its weight of water is heated and agitated with calcined gypsum or other pulverulent fiber, to form a wall-coating.

U. S. P. 1,194,926/16 Anderson. A floor composition is made of anhydrous calcium sulphate 100, mixed with Portland cement 15, pumice 20, sawdust 20 parts and sufficient water to form a stiff paste.

U. S. 1,209,315/16 Malley. In forming roofing tiles or other building materials asbestos sheeting is joined to a wire fabric with sodium silicate and used as a lining for mixtures of asbestos and gypsum or magnesia.

B. P. 104,596/16 Curtis. A plastering material consists of lime and plaster in the proportion of about 3 to 1, sawdust equal in quantity to the lime and plaster, and 1% of a mixture composed to 3 parts of sand and 1 part of whitening or pow-

dered chalk. For outside work and for flooring, Portland cement may be used instead of the lime and plaster.

F. P. 479,695/16 Bustamante. Unbreakable plastic materials are made of animal or vegetable colloidal materials (e.g. gelatin) combined with filling materials such as chalk, lime, anhydrous lime sulphate, gypsum, gelatinous silica, mica, alabaster and the like, pure clay, quartz or chalcedony, plaster, kaolin, etc. The product serves as a porcelain substitute.

Can. 173,728/16 Ashenhurst. A heat-insulating material is made of finely divided asbestos, aluminum hydrate and calcium sulphate. It has a specific gravity of less than 1.

U. S. P. 211,028/17 Zappi. A mixture of boric acid 1, kaolin 5, fibrous asbestos 20, sawdust 30, and gypsum 44 parts, with water, is molded into slabs which may be used instead of plastering, for lining safes or vaults or for covering steam pipes or boilers.

U. S. P. 211,445/17 Hofman. A composition for plaster or building blocks is formed of clay 70 lbs., lime 14 lbs., gypsum 15 lbs., pulverized glass 1 lb., and hydrochloric acid 2 oz.

U. S. P. 1,230,085/17 Ashenhurst. A cellular heat-insulating material having a specific gravity of about 0.4 is formed of comminuted asbestos, plaster of Paris and aluminum hydrate which is formed in the mixture from aluminum sulphate and chalk.

U. S. P. 1,230,297/17 Hite. A heat insulation is formed by suspending powdered lime sulphate or other powdered mineral matter in a viscous mixture of starch and water until a self-sustaining mass is obtained which is allowed to set in a mold and is then dried to produce a porous material.

U. S. P. 1,231,519/17 Gibson. A plastic composition for use as a cement or for making "artificial wood" is formed of plaster of Paris 7 lbs., gray ocher 7 lbs., waterproof varnish 1 gal., and formic acid 1 oz.

U. S. P. 1,245,021/17 Pierce. A composition for use as a plaster or for making tiles is formed of dry slaked lime 25, coke dust 50, ground clay 8.5, and a stucco 38 parts.

U. S. P. 1,245,723/17 Ito. A heat insulating material is formed by adding a solution of calcium bicarbonate and sodium bicarbonate to a mixture of kieselguhr 50, asbestos 20, magnesium carbonate 40 and calcium sulphate 40 parts.

U. S. P. 1,255,236/18 Schweimler. Tiles or building blocks are made from a mixture of plaster of Paris 1, cement 2, slag 2, and cinders 4 parts.

U. S. P. 1,257,488/18 Kemper. A plastic composition for building purposes is formed of calcareous waste from the manufacture of acetylene from carbide 8, Portland cement 1, plaster of Paris 3–4 parts, and sufficient water to allow molding into blocks, etc.

B. P. 115,163/17 Ito. A porous heat-insulating material is made from 100 parts of a solution of calcium bicarbonate and 4–7 parts of sodium bicarbonate, added to a mixture consisting of 50 parts of kieselguhr, 20 of asbestos, 40 of magnesite and 40 of anhydrous gypsum. Liberated carbonic acid renders the product porous.

Jap. P. 31,488/17 Adachi. Gypsum waste is dehydrated, treated with alum or other soluble sulphate, and heated. A cement for building purposes is thus produced at a low cost.

U. S. P. 1,256,324/18 Jump. Building blocks highly resistant to water are formed from a mixture of 0.2 normal rosin soap solution 10, 0.1 normal copper sulphate solution 5–7.5, calcined gypsum 50, and water to make a total of 100 parts. Ingredients which may also be used include alum or aluminum sulphate, lead acetate, ferrous sulphate, zinc sulphate, nickel or manganese or magnesium sulphates, barium

chloride and ferric chloride. A small amount of acid lessens the metallic salt required.

U. S. P. 1,266,200/18 Blumenberg. A plaster composition is prepared from equal amounts of dead-burnt gypsum and semi-hydrated gypsum.

U. S. P. 1,268,000/18 Funck. A plastic composition for use as a substitute for wood in posts or building construction is formed of lime 2, plaster of Paris 2, cement 5, and sand 10 parts mixed with water.

U. S. P. 1,283,546/18 Olson. About 1% of animal, vegetable or mineral oil, tallow, wax or similar dry oleaginous material, in anhydrous condition, is ground with dry cementitious material such as lime or gypsum plaster to prepare a waterproof cement.

U. S. P. 1,287,453/18 Sanderson. A mixture suitable for use in surgical work and for other purposes is composed of plaster of Paris 41, boiled linseed oil 2, resin 11, and carnauba wax 3 parts.

B. P. 117,605/18 Hartner. Anhydrite is ground with alkaline materials such as oxides or hydrates of alkalies or alkaline earths or with materials containing lime, such as cements, slags and waste lime or mortar, the addition of a small quantity being sufficient to cause the anhydrite to set like burnt plaster of Paris. Inert or filling materials may be added.

U. S. P. 1,300,493/19 Seaton. Plaster is united to concrete by an intervening layer of a viscous drying oil such as linseed or China wood oil mixed with asbestos or other fibrous material.

U. S. P. 1,301,893/19 Armstrong. A mixture for making plaster-board is formed of calcined gypsum 85 lbs., ground tan bark 15 lbs., a "hastener" such as dextrin 2 lbs. and about 30 lbs. water for each 100 lbs. of the other ingredients.

U. S. P. 1,308,931/19 Catlett. An oxy-salt such as 1.5–5% of calcium oxychloride is added to lime during slaking to facilitate complete hydration. Plaster or mortar prepared from lime thus slaked is stated to possess greater plasticity, harden more rapidly, and ultimately to become harder and more resistant to water than that made from lime slaked with water alone. Oxy-chlorides or other oxy-salts of magnesium, zinc or other metals effect similar results. The resulting plaster may be used as a substitute for Keene's cement. The oxychloride is made by the interaction of ground lime 100, 75% calcium chloride 60, and water 50 parts.

U. S. P. 1,304,148/19 Best. A fine grade of Keene's cement is produced by burning gypsum at a temperature of at least about 650°, mixing the burned product with a neutral catalyst, such as 1% of potassium sulphate, and grinding to about 150 mesh.

U. S. P. 1,327,446/20 Schumacher. Plaster board is formed by coating paper with plaster composition and coating the layer with paper so as to leave portions of the plaster uncoated, these portions being waterproofed by tar paint or other material and serving to form interlocking or attaching devices.

SLAG CEMENT AND KINDRED COMPOSITIONS

G. P. 225,803/08 Grau. Utilizing blast furnace slag by granulating it, in a dry state, then grinding, moistening, and compressing into blocks.

U. S. P. 935,617/09 Trembour. Cement made from molten furnace slag and a solution of gypsum in dilute acid.

B. P. 8,765/09 LaFarge. Manufacture of slag cement. Adding to the charge of an iron blast furnace suitable quantities of alumina and lime to impart to the slag the proper composition.

C. P. 231,367/09 Hohrath. In the manufacture of artificial stone from blast furnace slag with or without magnesia, sand, or the like, finely divided aluminum is added to the fused mass to increase the homogeneity and susceptibility to polish of the product.

U. S. P. 977,681/10 Schumacher. Making artificial stone by compressing coarsely disintegrated granulated slag with or without 2% lime, heating, and steaming under pressure.

B. P. 3,960/10 Berner. Manufacture of artificial stone from blast furnace slag and Roman cement, pozzolana or slag cement.

B. P. 17,109/10 Grau. In the utilization of blast furnace slag, the slag is ground dry to a coarse-grained clinker, during which process the heat of the grains exercises a secondary action, whereupon the mass is ground, moistened and compressed to stones or bricks.

G. P. 229,626/10 Muller. Slag cement produced according to 221,329 by mixing slag sand with gritty lime, slaked with regard to the water content of the slag, so that after mixing the lime is completely slaked. In the present invention the mixture of slag sand and slaked lime is not fully dried but is pressed in a plastic moist state in a mold into stones.

G. P. 250,433/10 Elsner. In the manufacture of slag cement, blast furnace slag is allowed to act with a suitable amount of lime, and with substances which yield calcium aluminate at 900 deg. C., in the presence of sodium chloride.

U. S. P. 982,945/11 Forell. Making cement by adding lime to molten furnace slag in a rotary kiln, passing heated air or oxygen through the kiln, mechanically agitating the material so as to separate and project portions of the material through the air or oxygen to desulphurize the mixture, and disintegrating the product by jets of steam.

U. S. P. 983,024/11 Bruhn. Making cement by incorporating alkali salts, e.g., sodium or potassium carbonate or chloride, or hydroxide, or alum, with molten furnace slag, granulating and cooling the slag, and adding Portland cement.

U. S. P. 998,357/11 Lessing. Making cement from liquid furnace slag by repeatedly projecting the slag in a divided condition across an air current carrying powdered lime in suspension. Further treatment may be applied, with water carrying lime or barium carbonate in suspension.

U. S. P. 1,004,380/11 Deher. Making cement by mixing with blast furnace slag, while still fluent, lime and aluminous material and then granulating and drying the mixture so formed.

G. P. 263,179/11 Elsner. In the manufacture of slag cement the crude slag, ground with additions to the required fineness, is stirred up with an aqueous solution of alkali chlorides and salts of aluminum and magnesium, so as to form a slurry, and the mixture is burned in a furnace.

U. S. P. 1,036,712/12 Ramsey. Making a cementitious material from blast furnace slag 90, sodium hydrogen carbonate 2, calcium oxide 5, iron oxide 1, chrome alum 1, silica 1 and steam.

U. S. P. 1,068,396/13 Schol. Making light bricks from furnace slag by leading the molten slag and compressed air into water to form the slag into light lumps and granules, sifting out the granules, giving the lumps a hard coat of cement, mixing them with a binder formed of the granules by grinding and mixing with lime, and shaping the mixture.

G. P. 272,174/13 Bruck. In a method of reducing the sintering temperature of crude cement masses, the materials separating from blast furnace gases are added, instead of the heretofore used finely ground ores of iron or manganese.

F. P. 17,531/13 Schol. Addition 437,595. In the manufacture of light artificial stone from blast furnace slag, cement or lime is used as the binding agent instead of powdered slag. Basic slags are mixed in a molten state, with pumice stone, quartz, or aluminum silicates, for the production of spongy masses; the effect of porosity and strength depending less on the silica than on the alumina content of the silicates.

F. P. 453,417/13 Dumas. An artificial stone consisting of cement (ground firebrick), sand, tufa-stone, and slag.

F. P. 463,362/13 Vielajus. In the utilization of slags of the manganese-silicon-iron alloys of the electric furnace in the manufacture of artificial Portland cement, lime or limestone is worked up with the slags, in the dry or wet way.

U. S. P. 1,094,876/14 Carson. Making cement by fine grinding a high alumina slag (e.g., from Cuban iron ores) and lime together, and adding water or steam to partly hydrate the mixture but less than is required to cause setting.

U. S. P. 1,115,321/14 Lessing. Making cement from molten blast-furnace slag by violently projecting the slag into a cooled rotating horizontal tube and passing the slag through the tube against a current of air and steam.

B. P. 114,794/17 Deckers. Slag cement is made by grinding granulated slag under water, drying, e.g., by centrifugal means, until the water content is reduced to 4.7%, mixing with ground lime in the required proportions, and finally grinding the mixture.

U. S. P. 1,343,948/20 Wennerstrom. Broken pieces of lime or limestone are delivered on to the surface of a body of slag in an electric furnace, and an electric current is passed through the slag to heat it sufficiently to melt the lime and effect its combination with the slag to form a cement.

B. P. 145,569/20 Link. Blast-furnace slag is mixed with burned earths rich in silica such as brick-dust, clinker, chamotte, stoneware and porcelain, and the mixture is finely ground to produce a substance similar to trass for use in mortar.

U. S. P. 1,348,099/20 Ellis and Riederer. A structural mass of concrete having a superficial layer containing distributed therethrough copperized iron granules of a size between 10 and 30 mesh and being substantially free from fine dust and being sufficiently coarse to form a substantial part of the wearing structure of the concrete yet fine enough to be readily incorporated with the concrete material without unfavorably modifying its texture.

U. S. P. 1,348,494/20 Horn. The process of treating lime which comprises commingling a stream of quick lime with a stream of water in approximately equivalent proportions whereby hydration ensues and in adding a stream of fatty acid to the reacting mass while the latter is progressing through a reaction chamber.

U. S. P. 1,349,901/20 Meischke-Smith. A ferroconcrete construction comprising a body of cement and reinforcing units distributed in indiscriminate directions throughout the cement body consisting of disconnected pieces of flat steel wire having flat faces.

U. S. P. 1,351,874/20 Schaller. A composition adapted to form a light weight cement for finely cut and ground vegetable material, comprising 20 lbs. of casein, from 20 to 30 lbs. of lime, from 2½ to 1¼ lbs. of caustic soda, and from 5 to 2½ lbs. of borax.

D. P. 1,354,233/20 Bayer. Method of treating pumice stone so that it is rendered suitable for light concrete, characterized in that the pumice stone is crushed, and the separate fragments are subjected to a temperature of about 1000° C. and higher up to melting point, whereby there occurs a contraction in each separate fragment, which contraction according to the height of temperature, increases the hardness until glass-hardness, and whereby the outer pores in reaching the melting point are completely closed through a superficial melting while each separate piece still remains porous inside.

B. P. 1,359,434/20 Scarlett. A cement comprising an intimate mixture of substantially 50 parts by weight of Swedish pitch, 24.5 of rosin, 9.5 parts of cotton seed oil, 14 parts of paper pulp, and 2 parts of calcic-hydrate.

U. S. P. 1,363,045/20 Kramer. A building material compounded substantially as follows: furnace slag, 79.8%; cement, 20%; hydrofluoric acid, .025%; permanganate of potassium, .175%.

U. S. P. 1,363,879/20 Junghandel. A composition of matter for use in making artificial stone consisting essentially of cement and an aggregate of calcined rice hulls.

U. S. P. 1,365,077/21 Ashenhurst. A cementing composition of dry solids and consisting of the finely ground double silicate of calcium and magnesium as produced from the waste of asbestos mills, and a water-soluble salt, said composition when combined with water being adapted in and of itself to form a cement which will adhere to highly heated surfaces.

U. S. P. 1,370,581/21 Brookby. A calcined gypsum product comprising commercial plaster of Paris carrying in intimate association substantially one-tenth of one per cent. of its own weight of a deliquescent chlorid of an alkaline earth metal.

G. P. 1,371,762/21 Hartner. A mortar forming material comprising gypsum anhydrite ground with a small percentage of substance having setting properties and an alkaline reaction.

I. P. 1,372,015/21 Ferrari. A slow setting calcareous cement free from binary calcium compounds of alumina or iron generally used, which is prepared by converting into slag a raw mixture of the ordinary type used for Portland cement, in which the proportion between the oxids Fe_2O_3 and Al_2O_3 is comprised between 1 and 1.563.

U. S. P. 1,372,118/21 Collier. Method of producing an article comprising a fibrous body and a cementitious binder, which consists in suspending a fiber and magnesia in a liquid, depositing them simultaneously therefrom in the form of a sheet or article upon a foraminous support, and then causing a solution containing magnesium chlorid to flow through the deposited layer while carried by said support until the magnesia therein is converted into oxychlorid.

U. S. P. 1,374,403/21 Smith. A process of curing articles of cement, cement mortar or cement concrete which consists of the following steps: first, confining the article in a closed pressure cylinder; second, subjecting the article to pressure by means of compressed air or gas; third, applying heat to the article by means of heating the air or gas surrounding the article, always, however, keeping the pressure of the compressed air or gas in the cylinder greater than that of saturated steam having the temperature of the water in the pores of the article; fourth, after the final set of the cement, mortar, or concrete, further applying heat without reference to pressure of air or gas and temperature of water in pores, until any desired strength of the article is attained; fifth, releasing the pressure in the cylinder to that of the atmosphere; sixth, removing the article from the cylinder.

U. S. P. 1,376,464/21 Sanderson. Artificial stone including approximately 5 cu. ft. of sand, 3¾ lbs. of red oxid of iron, 2½ lbs. plaster Paris, 1¼ lbs. ocher, 1¼ lbs. salt, 10 oz. sugar, and 95 lbs. cement.

U. S. P. 1,379,680/21 Formby. The process of producing a cementitious product which consists in providing a mixture of calcium and magnesium oxids with calcium and magnesium hydrates; reacting on said mixture with hydrochloric acid and adding the mass thus produced to a hydraulic cement.

U. S. P. 1,385,757/21 Smith. A plastic composition comprising cement, coal ashes and brick dust of substantially equal proportions.

U. S. P. 1,386,914/21 Tufts. A process for making a dry cement product, consisting in agitating calcined magnesite in a closed vessel, and introducing therein during said agitation amounts of hydrochloric acid gas and water vapor sufficient to produce a product containing the proportion of 5 molecules of magnesium oxid, 1 molecule of magnesium chlorid and 5 molecules of water.

U. S. P. 1,388,011/21 West. A metallic cement composed of oxid of iron, oxid of zinc, litharge and comminuted aluminum, made into a plastic mass by the addition of dissolved water-glass.

U. S. P. 1,402,133/22 Ashenhurst. A new composition of matter composed of

gypsum containing a retarding chemical, aluminum sulphate, magnesium carbonate and water.

U. S. P. 1,404,438/22 Holmberg. A heat insulating and resisting material made by moistening a mixture of about 30% of magnesia and 70% of an infusorial siliceous earth with a saturated solution of magnesium chlorid and compressing such moistened mixture in a mold.

S. P. 1,406,421/22 Senan. A process for the manufacture of concrete possessing great resistance and rapid setting power, which consists in mixing with ordinary cement an extremely hard granular, crystalline, and igneous rock rich in silica and alumina and poor in lime, which has been heated for at least two hours at a temperature of 1000° C., and thereafter pulverized, together with fragments of rock of the same character as that mixed with the cement.

U. S. P. 1,407,194/22 Dufva. A cementing composition comprising linseed oil, a pigment, rosin, and minute metal particles.

B. P. 1,408,401/22 Richards. A method of making molded cement articles which consists in adding powdered clay up to 10 parts to a mixture of 30-45 parts of ground cement and fiber, and mixing the same therewith, then mixing the resultant composition with water to form a freely flowing mixture, molding the desired article under pressure.

Can. P. 1,409,091/22 Goddard. An elastic cement composition comprising cement and a filler or aggregate, a portion of said filler or aggregate being initially coated with an elastic substance.

U. S. P. 1,415,324/22 Erdahl. As a new product, concrete having the capillaries thereof coated with a non-porous insoluble film resulting from treatment with an alginate reaction-product formed by gelling a purified metal alginate with ammonia in the cold.

SILICEOUS MATERIALS

F. P. 400,020/08 Geofrey. Process of agglomerating talc to manufacture crayons, plaques, blocks, etc., by making a paste of talc powder with sodium silicate, and, after desiccating, heating to 500–1000 deg. C.

U. S. P. 933,982/09 Herbst. Composition for molds for casting artificial stone. Finely ground crystalline silica, with or without chalk 5%, made into paste with water.

U. S. P. 947,128/09 Robeson. Molded articles. Sand bonded by means of waste sulphite liquor, and coated with the latter.

G. P. 248,912/11 Ehlers. B. P. 17,226/11 Ehlers. Weather and acid proof building material, consisting of asphalt, 550, magnesia 250, ground leather scrap 75, resin oil 75, waterglass 50, concentrated alum solution 20, fine washed ignited sand 2500.

U. S. P. 1,030,114/12 Neil. Cement containing sodium silicate and glucose.

U. S. P. 1,060,614/12 McCarty. Making artificial stone by softening silica with nitric acid and hydrofluoric acid, mixing the softened mass with additional silica, adding a hardening material, e.g., lime or magnesia and acetic acid, and allowing the mass to set.

B. P. 243/12 Arthur. Alkali silicates in a solid brittle form containing from 10 to 30% of water are crushed and heated to obtain a light porous intumesced material suitable for heat-insulating, and having an apparent density 30 to 100 times less than the original material.

B. P. 1,066/12 Cambell. Silica bricks, etc., are formed by mixing together silica, soda or its equivalent, as in the form of carbonate, sulphate, or chloride, quicklime, and water, and molding, drying, and burning at a temperature up to 3000 deg. F. so as to bring about the formation of glass or like vitreous binding material. The proportions preferred are silica 96% and 2% each of soda and lime.

U. S. P. 1,049,410/13 Sharples. Artificial stone composed of silica and a vitreous binder and having a posterior cellular mass and a compressed face.

U. S. P. 1,076,126/13 Krieger. Making a building brick from kieselguhr by molding while moist and, after drying, heating to partially fuse and bind the mass together.

Aust. P. 9,445/13 Forbeser Kieselguhr Werke. Insulating, covering and finishing plates are made by mixing with water, to a thin slurry, kieselguhr 50, asbestos fiber 30, best kaolin 10 and gypsum 10%, pouring this mass into molds, and drying at 80° C.

U. S. P. 1,088,755/14 Wessling. Fire-brick formed of fine particles of silica bonded together with 2.5% of pulverized soapstone.

U. S. P. 1,088,756/14 Wessling. Making fire-brick by bonding finely divided silica with pulverized soapstone and water, molding and drying and immersing the dried brick in a bath of powdered silica and water before burning, to give it a smooth surface of vitrified silica.

U. S. P. 1,092,402/14 Scharwath. Making a heat-insulating material by heating a body of sodium or potassium silicate in an open mold of the shape of the finished product desired, and stirring until a uniform porous product is formed. Small amounts of magnesia, magnesium carbonate, infusorial earth or asbestos may be added.

U. S. P. 1,139,637/15 Caven. Light, porous bricks are made from kieselguhr by agitating it with water and successively added portions of sawdust or other vegetable fibrous material, molding, drying, and heating high enough to burn out the vegetable fiber.

U. S. P. 1,206,545/16 Kern. Building bricks from infusorial earth. A wet mixture of infusorial earth with clay having a low melting point is molded, pressed, dried by a current of air, burned and quickly cooled. The product is porous, fireproof and of low specific gravity.

U. S. P. 1,206,546/16 Kern. Electrolytic diaphragms, filters or other molded articles are made when diatomaceous earth containing acid-soluble metal compounds is treated with dilute hydrochloric acid to convert the latter into chlorides and form a moldable mass, molded, partly dried and burned at a temperature which converts the chlorides into oxides.

B. P. 108,619/16 Barrett. A porous, refractory product is made from a mixture of 4 cwt. silica (or vitrified siliceous material, such as sandstone, quartz or chert), 1 cwt. feldspar, 7 lbs. dextrin (or gum or the like), and 14 lbs. of tar. Some alkali silicate may be added. It is burned at a temperature of at least 2000 deg. F.

N. P. 26,731/16 Platsch. Non-hygroscopic, light-weight insulating material consists of quartz, together with material of a higher melting point. Air is blown through the molten quartz material to increase its volume.

U. S. P. 1,247,503/17 Caven. Diatomaceous silica is made plastic by grinding with water and this product is mixed with unaltered diatomaceous silica and with combustible matter and heated to cause fusion of the ground portion. The resulting porous material is used as a filtering medium or insulating material.

F. P. 482,095/17 Bleser. A pumice briquet is made of ground sandstone and pumice mixed with molten sulphur and colophony in varying proportions, and molded. The constituents are preferably in equal proportions.

Swed. P. 41,930/17 Baarnhielm. Cement pipes are cast from a mixture of powdered quartz with water and soda or potash waterglass to prevent cracks.

Jap. P. 31,638/17 Toyonaga. For a plastic composition there is used 8 parts of a hydromagnesium silicate or a hydroaluminum silicate (e.g., a mixture of diatomaceous earth, talc, serpentine or marble) which is heated with 3 parts olein and mixed with zinc white 1 part and hemp oil 2 parts. Some graphite and iron oxide are mixed with the product to impart color.

Jap. P. 31,708/17 Ito. A heat-insulating material is made from a paste composed of a mixture of diatomaceous earth, asbestos, magnesium carbonate and calcium sulphate with sodium bicarbonate solution.

U. S. P. 1,238,202/18 Schwerin. Dissolved silicic acid free from electrolytes is used for impregnating artificial stone or cement to harden it, or for impregnating wood, straw or textile materials without causing efflorescence. The silicic acid may be prepared electro-osmotically as described in U. S. P. 1,132,394.

U. S. P. 1,259,525/18 Kinnison. Sodium carbonate and water are used as bonding agents in forming bricks or other articles from powdered kieselguhr.

U. S. P. 1,260,398/18 Kennedy. Silica fire-bricks are formed of coarse particles of silica free from powdered material, mixed with a binder of fire-clay.

U. S. P. 1,262,887/18 Werner. A friction material suitable for use on brakes of various types is formed of asbestos mill board thoroughly impregnated with linseed oil oxidized by heat.

U. S. P. 1,279,975/18 Boeck. A heat insulating material is formed by adding a small quantity of alkali to a suspension of a hydrated basic magnesium carbonate, then adding diatomaceous earth and fibrous material to the mixture while hot, and molding.

U. S. P. 1,283,754/18 Headson. Heat insulating material for furnace walls is made by calcining finely divided diatomaceous earth 75 parts and fine asbestos 23 parts, mixing with a binder such as water and clay, molding, and allowing to harden. The product may be finally burned at about 1100 degrees.

B. P. 118,116/18 L'Ouest. Silica bricks are made from quartz or quartzite containing about 95% silica. After disintegrating or after cooling, the material is crushed, part being a fine flour; it is mixed with a binder such as lime, molded and burned.

B. P. 118,768/18 Ardagh. Plastic compositions are made from selected silicate cotton by grinding and mixing with an alkali silicate solution. The composition may be used with fibrous materials or other fillers to make stiff fireproof sheets.

B. P. 124,597/18 Lonsdale. A non-conducting coating is made from sodium silicate, white asbestos fiber, blue asbestos fiber, asbestos powder, kieselguhr, sand, quartz and hydrochloric acid, applied to articles in a series of coats containing different proportions and combinations of the materials.

B. P. 129,505/18 Olson. A heat-insulating material which may be rendered abrasive by calcining consists of 88% of dry pulverized infusorial earth, 1% sodium sulphate, aluminum sulphate and 10% lime. Similar sulphates or a double sulphate may replace those mentioned. The mixture is gaged or wet with water and molded into bricks, etc. It may be dried and calcined at 800–2700 deg. F., forming a crystalline substance having abrasive qualities.

U. S. P. 1,297,724/19 Patrick. A hard, transparent, porous silica gel having high absorptive properties is prepared by adding enough hydrochloric acid to a solution of sodium silicate to set free all the silica, allowing the gel thus formed to set, washing, drying in a current of air at 75–120 deg. and then subjecting it to a vacuum.

U. S. P. 1,307,548/19 Headson. A heat-insulating composition adapted for furnace walls is formed of finely divided calcined diatomaceous earth 75 parts, finely divided calcined asbestos 25 parts and a binder of clay or other fire-resisting material 3–10%.

U. S. P. 1,307,549/19 Headson. A heat-insulating brick adapted for fire-boxes or furnace walls is formed of finely divided calcined diatomaceous earth 75% and finely divided calcined asbestos 25% firmly united into a rigid body.

U. S. P. 1,314,753/19 Overbury. Mineral-surfacing material such as crushed slate used for roofing is treated with a transparent layer of material such as sodium

silicate to prevent subsequent changes in color by oily substances contained in the roofing fabric.

U. S. P. 1,317,853/19 Ashenhurst. An asbestos cement is prepared composed of finely divided particles of double silicate of magnesium and calcium having a weight of approximately 25 lbs. per cu. ft.

B. P. 123,992/19 Frydenlund. Baked porous building and insulating bodies are made from a mixture of kieselguhr and the pith of plants, such as Helianthus annus, which is burned out during the baking process.

Norw. P. 30,250/19 Intern. Isolations Kompani. A finely ground mass of diatomaceous or infusorial earth is mixed with granulated organic matter which has been heated repeatedly to 100 deg. and water is slowly added in the proportion of 45–60% of the weight of the mixture. The mass is then shaped, dried at 20–50 deg., heated slowly in the mold to 250 deg., and finally burned at 800–1000 deg.

U. S. P. 1,330,249/20 Emley. A brick suitable for oven walls is formed with a backing or body portion of cellular material made up of infusorial earth and a heat-resisting cement binder and a facing of harder vitreous material anchored in the body portion.

U. S. P. 1,332,348/20 Macdonald. A heat-insulating material adapted for coating steam boilers or pipes is formed of infusorial or diatomaceous earth 100, an alkali, e.g., sodium or potassium hydrates, or soda ash 1%, part at least of which is combined with the insulating earth in the form of a silicate, starch 3% and water so mixed that air cells are left in the material when it is dried.

U. S. P. 1,332,370/20 Winkley. A heat-insulating material adapted for use on boilers or steam pipes is formed of heat-insulating earth, e.g., infusorial earth 85, soda ash 5, slaked lime 2, starch 10 parts and water.

U. S. P. 1,345,666/20 Donavon. A heat-insulating material is formed by molding a block of kieselguhr with pieces of fruit pits or nut shells and then burning out the latter to leave a porous mass.

U. S. P. 1,351,087/20 Sutter. A waterproofed structural material for use in ovens, refrigerators or buildings is formed of kieselguhr and a refractory binder and an insoluble soap.

G. P. 294,330/16 Gallenkamp. Silicate coatings are composed of an inorganic dye dissolved in a water glass solution which is then coagulated by sodium bicarbonate.

Swiss. P. 73,260/16 Caudemberg. An elastic, waterproof product, absorbing vibrations, is composed of a mixture of gas tar with rubber dissolved in benzene and carbon bisulphide, ordinary cement, and mineral filling.

U. S. P. 1,220,575/17 Wedge. Ground quartz, diatomaceous earth or similar fine material is treated with oxalic, stearic, or oleic acid and then with sodium silicate to effect precipitation of colloidal silica upon the particles and form a product which is resistant to the action of water and acids.

U. S. P. 1,221,445/17 Harrison. A powder for adding to concrete as a waterproofing agent is formed by mixing plastic clay with about 5–25% its weight of neutral fatty acid glycerides, e.g., lard, tallow or cottonseed oil, dissolved in a volatile solvent such as naphtha, and then evaporating the latter.

U. S. P. 1,225,129/17 Hochstrasser. Finely comminuted cement is sifted into water to form a colloidal mixture, the excess water is drained off and the residue is then mixed with the coarser ingredients of the concrete. This treatment gives a product substantially waterproof and resistant to acids and alkalies.

U. S. P. 1,242,585/17 Olson. A mixture of slaked lime 50 lbs., alum 1 lb., water 2 gals, and crude petroleum or other hydrocarbon oil 3 gals. is heated with steam under pressure, and cement or plaster is then treated with about 5% its weight of this mixture to waterproof it.

U. S. P. 1,245,982/17 Satow. A highly polished coating resembling glazing is

produced upon brick, tile, cement, glass, paper or other materials by use of a lacquer made from vegetable proteins, a phenol and formaldehyde, trioxymethylene or hexamethylene tetramine as described in U. S. P. 1,245,981.

B. P. 114,641/17 Linden. Concrete is made of 100 parts cement mixed with 5 parts dry powdered moss or turf, 20 parts iron ore, and with a liquid consisting of 5 kg. lime and 3 kg. aluminum sulphate in a cubic meter of water. The product is suitable for making pipes, casks, boats, and other forms exposed to water or weather.

Norw. P. 27,827/17 Lindemann. The pores in cement are filled with an insoluble sulphate such as barium by the action of sulphuric acid on a soluble compound.

U. S. P. 1,255,116/18 Horn. Ammonium resinate is added to concrete to accelerate the formation of colloidal substances in Portland cement and render it more nearly waterproof.

U. S. P. 1,262,344/18 Holzapfel. A cement wash is applied to concrete and allowed to harden to provide a smooth surface. This is coated with a bituminous wash containing asphaltum, coal-tar, pitch, and "coal-tar spirit," with an overlying coating of paint composed of asphaltum, coal-tar pitch, heavy tar oil, benzol, linseed oil, litharge and iron oxide.

U. S. P. 1,285,636/18 Davidson. About 0.25–1.00% of naphthenic acids such as obtained in refining Russian petroleum are added to cement as a waterproofing agent. The acids may be allowed to combine with the lime of the cement, or the chloride of barium or aluminum may be added to form insoluble naphthenates.

B. P. 120,198/18 Horn. A solution of ammonium resinate, with or without ammonium compounds of fatty acids (stearic, oleic, etc.) is added to the water mixed with Portland cement in making concrete. Half to two per cent (as anhydrous) is added.

B. P. 123,695/18 Olson. Cements which set in water and have an alkaline reaction are rendered waterproof by spraying them during the grinding process of manufacture or during regrinding with about 1% of an oleaginous or bituminous substance. A preferred mixture is 75 parts residue mineral oil and 25 parts beef fat or stearin.

B. P. 128,452/18 Mulligan. A compound to be added to ordinary cement to strengthen it and render it waterproof consists of thoroughly slaked lime and raw linseed or equivalent drying oil. For example: 3 oz. of oil are mixed with 20 oz. of lime, and 0.5 oz. of the compound is added to 1 lb. of sand and ordinary cement.

B. P. 131,164/18 Scott-Moncrieff. About 40 parts of oil shale residue and 40 parts of Norfolk chalk are ground together and clinkered for the manufacture of cement, which is then ground and mixed with 30 parts of raw shale to form a waterproof cement. The product may be used for making roads, flooring, roofing walls, or for constructing culverts, etc.

F. P. 485,845/18 Kelly. A refractory cement, impermeable to water and acid-proof, is obtained by mixing soluble glass with an adhesive liquid insoluble in water and difficultly saponifiable, and hydrated Portland cement. A filling material may be added to the product, which may be molded with or without reinforcement.

F. P. 486,316/18 Grevisse. Lime and cement are directly hydrated and carbonized by means of carbon dioxide generated in lime kilns or otherwise. The product is unaffected by sea-water or by magnesium, or sulphate waters.

Holl. P. 2,399/18 Mecke. Cement and lime plaster are waterproofed by incorporating with mortar an insoluble metal soap treated with an alkaline earth hydroxide.

U. S. P. 1,305,645/19 Cabot. A paste formed of powdered pitch mixed with water and soap, dextrin or other protective colloid is used as a waterproofing agent for cement.

U. S. P. 1,323,953/19 Baylor. About 30 lbs. of "slops" from paraffin manu-

facture or similar unsaponifiable or waxy material, is added per ton of cement as a waterproofing agent.

U. S. P. 1,331,217/20 Schutte. A waterproof concrete which is of good wear-resisting quality and suitable for roadways is formed of hydraulic cement with its cells filled with bituminous cement. The material adheres well to old cement work.

U. S. P. 1,348,494/20 Horn. Lime is treated with water in such amount as to produce a dry powder and before the hydration is completed a fatty acid such as stearic acid or a resin acid is added in order to produce a material suitable for waterproofing Portland cement.

WHITE CEMENT

B. P. 14,336/08 Kelly. White cement is made from chalk, clay and salt.

B. P. 18,887/09 Blanc Co. A white stainless cement is made by mixing calcium carbonate, a siliceous material and a salt of zinc, all free from iron, burning this mixture and powdering the clinker.

G. P. 242,818/09 Muller. White cement is obtained from a mixture of magnesia, calcium sulphate, and magnesium sulphate.

B. P. 18,338/10 Rhodin. Manufacture of a white hydraulic cement from material with a large constant of aluminum silicate (feldspar) by mixing such material and lime in finely divided condition with common salt and an aluminum compound, also finely divided, with or without addition of magnesium sulphate, and heating the mixture to a temperature above 900 deg. C., but below such temperature as would render regrinding necessary, or would cause discoloration.

B. P. 19,346/10 Accettola. Artificial marble is made from white Portland cement mixed with powdered Darbyshire spar, or marble dust, or sand, to which ground glass may be added.

B. P. 29,301/13 Barter. A composition for making floors, walls, etc., consists of 180 lbs. of white Portland cement, 144 lbs. of ground calcined flint, 144 lbs. of coarse calcined flint, 18 lbs. of stone dust, and 1 lb. of calcium chloride dissolved in 1 gal. of water.

B. P. 14,865/14 Hannon. A white hydraulic cement is made by burning mixtures of argillaceous and calcareous materials containing a small proportion of iron compounds in the presence of a chloride (1 to 4%) of an alkali or alkaline earth metal, at a temperature of about 1000 to 1250 deg. C.

B. P. 8,551/15 Gresly. A slowly setting, white, hydraulic cement containing little or no alumina or iron oxide is made by adding calcium sulphate as the sole sintering agent to a mixture of lime or limestone and silica or to calcium silicate or limestone containing silica, then sintering, and grinding. The materials used may be crude, or may have been previously heated and suddenly cooled. As an example, 34 parts of calcium sulphate are mixed with 250 parts of calcium carbonate and 60 parts of silica.

U. S. P. 1,224,454/17 Ellis. A mixture of orthoclase and limestone is heated to a temperature somewhat below the volatilizing point of the potash compounds formed, the hot product is quenched with a solution containing calcium chloride, and the material is then rapidly heated to form cement clinker and volatilize potash compounds, including principally chloride, which are recovered from the clinkering kiln.

U. S. P. 1,239,579/16 Ewing. A white cement mixture is formed of ordinary Portland cement 20 and diatomaceous earth and slaked lime each 1 part.

U. S. P. 1,239,912/16 Helbronner. White Portland cement is made by heating ordinary ferruginous raw cement-forming materials progressively up to 1400–1500 deg. with calcium chloride, with a blast of air and super-heated steam, thus effecting volatilization of the metal chlorides, particularly iron chloride.

DENTAL COMPOSITIONS

G. P. 230,578/08 Eisenlohr. Manufacturing a glass-like mass for dental purposes by fusing together quartz, aluminous substances, alkali and alkaline earth compounds and substances containing phosphoric acid.

G. P. 256,212/11 Kruse. A material for manufacturing artificial teeth, consisting of magnesia, a cold-saturated aqueous magnesium chloride solution, and an alcoholic resin solution, which is cast in a form in the liquid state, where it solidifies to a hard mass, with an enamel surface.

B. P. 12,806/15 Davis. Dental alloys, to be amalgamated with mercury for use as stoppings and consisting of the usual mixtures of silver, copper, zinc, aluminum, bismuth and silicon together with gold, are made in granular form with some of the gold applied as a coating by chemical or electrochemical action.

G. P. 292,406/15 Caspari. In making artificial teeth from a ceramic mass flour, tragacanth, glue, or the like, is added to the mass so that the compressed and hardened tooth may be worked before burning and so shaped as desired.

U. S. P. 1,172,723/16 Miller. Dental cement is made by mixing boric acid or borax with powdered washed beryl and sodium aluminum fluoride, the mixture is saturated with pyrophosphoric acid and formed into a thin paste with water and heated to obtain a melt which is cooled and powdered and subsequently prepared for use by the further addition of pyrophosphoric acid.

U. S. P. 1,176,176/16 Smith. Amalgams for use in dental work are cooled and kept in a frozen condition until desired for use and are then heated to render them plastic.

U. S. P. 1,205,957/16 Albrecht. A liquid for filling and preserving roots of teeth is formed of resorcinol or pyrogallol 5, an aqueous solution of formaldehyde (1.081 sp. gr.) 25 and glycerol 25 parts, with a little sodium hydrate, sulphuric acid or other condensing agent. The solution will penetrate the smallest cavities and is slowly self-hardening.

U. S. P. 1,209,906/16 Thurston. Spongy gold or other spongy metal for inlay fillings or other dental work is heated with a semi-liquid solution of resin in cocoanut oil or cottonseed oil or a similar mixture to fill the pores of the spongy metal so it will retain its shape during manipulation. The resinous mixture is removed by heating.

U. S. P. 1,210,555/17 Smith. In preparing dental cements from any commonly used ingredients, the constituents of the cement are refrigerated during the mixing operation to prevent chemical combinations until they are thoroughly incorporated and ready for immediate use.

U. S. P. 1,226,232/17 Mahan. A dental cement is formed of copper silicate 2.5% mixed with oxides of zinc, bismuth and manganese. It is prepared for use by adding phosphoric acid and alumina.

U. S. P. 1,245,879/17 Crowell. Silver acid phosphate or other germicidal silver salt is mixed with an oxyphosphate of zinc cement powder and an acid phosphate liquid. The silver salt causes coagulation of fluids of the dentinal canals.

B. P. 110,154/17 Andresen. A condensation product is obtained from the action of formaldehyde on eugenol (or oil of cloves, etc.) The product is suitable for dental use. The original materials may be mixed with burnt alum, and the pasty product mixed with zinc oxide.

B. P. 118,701/17 Crowell. Silver salts are incorporated with dental cements for tooth-stopping or for setting crowns, etc., to exert antiseptic effects and prevent the recurrence of decay. Silver phosphate may be mixed with the powder of an ordinary zinc hydroxyphosphate cement, or the phosphate, carbonate, oxide, or other salt of silver may be dissolved in the phosphoric acid solution with which the cement powder is mixed for use. This solution may also contain the phosphates

of zinc, aluminum and sodium. In place of silver phosphate, other salts such as borate, silicate, chloride, bromide, or iodide may be employed.

B. P. 118,702/17 Crowell. Mercury salts are incorporated with dental cements as antiseptics. A mercury phosphate or other mercurous or mercuric compound such as oxide, sulphide, chromate, or carbonate is added to the powder or to the phosphoric acid solution of an ordinary hydroxyphosphate of zinc cement. The acid solution may contain in addition, the phosphates or oxides of sodium, zinc or aluminum.

U. S. P. 1,294,355/19 Black. A powdered mixture for preparing dental fillings is composed of nitrocellulose 100, gum amber (measured as a saturated solution in chloroform, the latter being evaporated in the preparation of the powder) 40, and powdered silica 25 parts. When this mixture is used for filling cavities, it is made into a plastic mass by adding a solvent mixture composed of acetone 2 parts and a saturated solution of gum amber in chloroform 1 part.

U. S. P. 1,310,901/19 Andresen. A cement suitable for temporary fillings in teeth is prepared by mixing together zinc oxide 45 parts, burned alum 15 and a condensation product of eugenol 15 and formaldehyde 2 parts (or phosphoric acid, zinc sulphate or zinc chloride).

B. P. 134,757/19 Andresen. A dental cement consists of zinc oxide, alum, and a suitable liquid such as water. Eugenol, oil of cloves, zinc sulphate or zinc chloride copper sulphate, phosphoric acid or a condensation product of eugenol and formaldehyde may be added to increase the depth of the anesthetic effect. Suitable proportions are 45 parts of zinc oxide, 15 of burned alum and 15 parts concentrated solution of zinc sulphate or other substance above mentioned.

B. P. 136,757/19 Beville. An adhesive for the fixation of artificial dentures consists of a mixture in the form of powder of gum tragacanth or similar gum with a substantially insoluble substance such as calcium carbonate, zinc oxide, calcium phosphate, talcum, kaolin, kieselguhr, zinc carbonate, zinc oleate, zinc borate, slaked lime, starch or a mixture of such substances. An antiseptic such as boric acid or thymol, and flavoring and coloring agents may also be added. A preferred composition consists of gum tragacanth, calcium carbonate, boric acid and carmine.

B. P. 145,052/20 Schiff. Colloidal silicic acid in the form of hydrogel, acetogel, or alcogel, is added to dental cements of the kind in which phosphoric acid or acid phosphate is an ingredient, to prevent the liberation of acid after the cement has set.

U. S. P. 1,349,592/20 Turner. A tooth filling liquefied cementitious material for saturating a fibrous filling whereby the filling will solidify and harden when subjected to water, consisting of gum sandarac and gum camphor dissolved in alcohol.

G. P. 1,408,960/22 Schiff. A process of making dental cements consisting in bringing together pulverulent metallic compounds capable of forming a solid compound comprising a silico phosphate salt and phosphoric compounds containing oxygen and adding silicic acid in colloidal condition.

U. S. P. 1,413,071/22 Swartz and Ottmyer. A vulcanizable dental base plate composition comprising approximately 32% rubber, 10% sulphur, and 58% compounding ingredients including pigments and coloring matter, which, when vulcanized produces a strong, hard, tough substance suitable for making denture base plates and having a color approximately the pink color of the natural gums of the human mouth.

PORTLAND CEMENT AND COMPOSITIONS CONTAINING PORTLAND CEMENT

F. P. 390,290/08 LaFarge. Cement is made by melting bauxite and lime together.

Fr. 391,454/08 LaFarge. Cement is made by melting bauxite or iron mineral and lime, with slag.

B. P. 8,193/09 LaFarge. A cement is made by melting a mixture of bauxite or similar aluminous or ferruginous material poor in silica, together with lime; rapidly cooling, granulating and grinding the product.

U. S. P. 933,979/09 Gustiana. Face portion of floor tile formed from Portland cement 97 parts, chloride of lime 1, waterproof compound 2, water 8; back of tile Portland cement 33, fine gravel 67, water 8. The two portions are compressed in a mold to form one body.

U. S. P. 934,710/09 Brany. Artificial stone made of Portland cement 80, half saturated salt water 10, saturated lime water 10. The mass is molded and allowed to crystallize.

U. S. P. 935,616/09 Todd. Vitrified cement, made of Portland cement 30–60, asbestos 5–20, sand 20–60, water 25–42. The mass is shaped, dried, dipped in a solution of soluble silicate and again dried.

U. S. P. 939,078/09 Peacock. Phosphate rock 100, silica 8.3, limestone 51.4 furnaced at about 1400 deg. C to form Portland cement and recover phosphoric acid by absorption in water.

U. S. P. 939,977/09 Carson. A cement is made when a mixture of aluminum 1 and calcium oxide at least 3 parts is ignited, and incompletely hydrated and set to form a dry powder. The preliminary mixture may be made by calcining together bauxite and limestone.

U. S. P. 943,157/09 Norman. Brake-shoe composition. Portland cement 2, blood 2, asbestos 1, ground bone 1.

G. P. 225,125/09 Ahrens. Artificial slate from fibre and hydraulic binders. Shaking the moistened raw material in a sieve before pressing, to loosen it up and evenly distribute the moisture.

G. P. 236,923/09 Picha. Manufactured stonelike material from cement and a filler. The materials are used in very finely powdered condition and are compressed dry.

U. S. P. 954,692/10 Phillips. Concrete composition. Cement 100, arsenic trioxide 6, mica 5, sulphur 2, sand 300 and gravel 700 parts.

U. S. P. 954,693/10 Phillips. Building brick. Cement 100, sand 4 times the bulk of cement, arsenic trioxide 6, mica 4, copper sulphate 3 and sulphur 1.

U. S. P. 954,694/10 Phillips. Road brick. Similar to the preceding, somewhat different proportions.

U. S. P. 958,194/10 Thomas. Making artificial building blocks with body portion of coarse agglomerate of low plasticity, and facing of fine aggregate of high plasticity.

U. S. P. 964,164/10 Kayser. Acid-proof cement composition consisting of Portland cement and 10–30% of the waste products of the manufacture of aluminum sulphate (containing 70–90% silica and 30–10% alumina.)

U. S. P. 964,544/10 Pelot. Artificial stone composition consisting of cement 36, clay 36, sand 168, Maumee 1 part and lime water.

U. S. P. 968,379/10 Marsden. Pottery product consisting of clay, kaolin, sand, feldspar, crushed porcelain or the like 60–80%, and Portland cement 40–20%.

U. S. P. 969,202/10 Segle. Making articles from asbestos fibres 1, and cement 1, water 2, filter-pressing at 1000 lbs. per sq. inch, allowing the cake to absorb water, shaping, and allowing to set.

U. S. P. 979,547/10 Norton. Forming sheets of fibre concrete by first forming a layer of dry, thoroughly intermingled asbestos fibre and hydraulic cement, compacting the layer while still dry to about half its original thickness, then applying a setting liquid and finally compacting the layer to about one-fourth of its original thickness.

B. P. 5,155/10 Zehrlaut. Manufacturing artificial marble from self-hardening hydraulic mortars, by rolling the damp body mortar in the form of lumps in dry colored veining mortar, so as to coat the lumps with the latter; the lumps are then shaped in a mold by pressing.

B. P. 17,093/10 Owen. In the utilization of slate waste by the addition of cement, (1) at least ½ of the slate is ground to impalpable powder, (2) a relatively small quantity of cement is used, (3) the material is subjected to heavy pressure. Portland or Sorel cement 6 parts is used to every one part of slate. When Portland cement is used, it is moistened with sodium silicate solution. The material is molded at 10 cwt. per sq. in. The molded articles are placed successively in a solution of sodium silicate and chloride of lime or magnesia.

B. P. 21,560/10 Mahler. In the manufacture of porous artificial stone, a mixture containing a gas developing substance is placed in molds. The formation of gas in the material causes it to press against the walls of the mold.

G. P. 238,330/10 Karger. Facilitating the hydration of plaster stones made of cement and filling stone, by subjecting the wet mass to a pressure of at least 1,000 kg. per sq. cm.

G. P. 244,726/10 Ahrens. Manufacturing plates from fibrous materials and a hydraulic binder by spreading the binder upon the fibrous material as it passes over the spreading device.

G. P. 261,454/10 Industriewerke. Manufacture of artificial stone. A hydraulic binding agent (cement or gypsum) is stirred with a large amount of water and allowed to settle. After decanting the excess of water, the material is compressed in a sack to remove the residual water.

Dan. P. 16,262/10 Poulsen. In the working of the process of 15,166 for neutralizing excess lime in Portland cement, at least 5% kieselguhr is added during the grinding.

U. S. P. 984,915/11 Heltzen. Making diaphragms for electrolytic cells by applying to asbestos cloth a mixture of asbestos fiber, lime and cement while plastic, the composition being caused to enter the fibers of the cloth and the excess liquid being withdrawn by suction; the diaphragm is then dried in an oven, treated with sodium silicate and tempered in water.

U. S. P. 991,499/11 Brand. Artificial stone made by mixing crushed hornblende 2, granulated carbon or coal cinders 1, and Portland cement 2 with water, allowing the mixture to stand in a mold for a day, placing in water for a day, and finally allowing the composition to stand in the open air for 18 days.

U. S. P. 1,000,545/11 Page. Preparing hydraulic cement concrete by mixing cement, sand, aggregate and water in the usual way, and then adding to the mixture before it begins to set a non-volatile mineral oil in quantity not more than 25% of the cement.

U. S. P. 1,000,944/11 Rauhoff. Concrete composition comprising a cementitious compound, fine iron dust and asbestos.

U. S. P. 1,001,582/11 Ellis. Making cement clinker by calcining cement material in a rotary inclined kiln section by heated flame gases and admixed water vapor, adding a limited amount of water to disintegrate the calcined material and form water vapor, transferring the latter to the kiln to aid in calcining, re-grinding the calcined materials and clinkering the re-ground material in a rotary kiln, the calcining kiln section drawing flame gases from the rotary clinkering section.

U. S. P. 1,007,199/11 Hermann. Composition for forming plastic wall coverings, consisting of cement 154, plaster of Paris 30, sand 96 and powdered coloring matter 30 parts, mixed with an adhesive consisting of resin 1 and dextrin 15 parts.

B. P. 8,085/11 Owen. Cement, concrete and like blocks are formed in paraffin wax molds, which are removed from the articles, after setting, by heat.

B. P. 8,086–8,087/11 Owen. Similar to the preceding.

B. P. 12,697/11 Rhodin. Hydraulic cement is manufactured from feldspar (orthoclase) by heating a mixture of the spar 100, with slaked lime 56, and common salt 40, at about 900 to 1000 deg. C., lixiviating with hot water until the contents of chlorine in the mass, calculated on the dry weight of the residue, corresponds to about 0.25% sodium chloride. Potash may be recovered from the solution by crystallization. To the wet residue in the proportion of about 100 (calculated as a dry product) is then added gradually from 40–70 of lime and mixed, the slurry so obtained is heated in a muffle to about 1000 deg. for about an hr. Instead of incomplete lixiviation, a salt solution may be added to the completely washed slurry.

B. P. 19,183/11 Stinebaugh. A cement composition used in place of concrete for building and like blocks, brake blocks, etc., consists of cement 8, carbonaceous matter such as charcoal 3, blood 1.6 and water 1.

B. P. 20,219/11 Pyke. Composite artificial stone consisting of a core and a facing; the core is made of a mixture of about 5 to 20 parts powdered blast-furnace clinker, 76 to 50 parts of sharp grit, and 30 parts of Portland cement, while the facing is made of about 65 parts of a mixture of crushed stone and sharp grit, 25 parts of finely ground Portland cement, 2 of shellac, 3 of alum and 5 of powdered silica. The stone is preferably hardened by standing in water for 10 to 20 days.

B. P. 20,535/11 Weiffenbach. A composition for making plaster or stucco is composed of cement (preferably Portland) 20, charcoal (preferably vegetable) 20, and siliceous earth (preferably infusorial earth) 1. When required for use the dry powder is mixed with water.

B. P. 20,630/11 Skilbeck. Plastic compositions consist of Portland cement, pitch, coal tar, river sand, furnace gray slag, ground granite, and coke breeze heated together in substantially equal proportions.

B. P. 24,775/11 Poulsen. In the manufacture of cements coarse underground Portland cement is mixed with raw but dried diatomaceous earth, such as tripoli, kieselguhr, infusorial and similar earths, in proportions calculated according to the chemical constitution of both materials, and the mixture is finely ground in order to assist the combination of surplus lime with the chemically active silica of the kieselguhr, etc.

G. P. 250,887/11 Weisflog. Addition to 249,910. In making a cement for lithographic stones, the magnesia and limestone of the product of the principal process is replaced by iron oxide.

G. P. 252,824/11 Bippe. Artificial stone is made by treating a hydraulic cement mass with a solution of a heavy metal salt, which may also contain pigments. Marble cement, alabaster cement, gypsum, Sorel cement, Portland cement, or the like, may be used, and pulverized marble is incorporated with it. To prevent rapid hardening glue containing blood albumin is added. The metal salt, as, 10% solution of zinc sulphate, is applied to the mold or base (preferably glass); dark mica, pulverized mother of pearl, celluloid cuttings and the like are sprinkled over it and the cement mass is then poured.

A. P. 2,988/11 Frollo. A cement is made from cement, turpentine, mineral filling, rosin, boiled linseed oil and water. This is used for plastering walls and cementing artificial stones, glass, etc., on building material.

U. S. P. 1,020,124/12 Brown. Hydraulic cement composition. Furnace slag, hydraulic cement, calcium chlorate, calcium sulphate.

U. S. P. 1,020,325/12 Stinebaugh. Paving block and brake shoe composition containing cement, charcoal and blood.

U. S. P. 1,036,508/12 Moross. Hydraulic cement formed of cement, siliceous material, asbestos, kaolin and slaked lime.

U. S. P. 1,038,115/12 Gillies. Process of making artificial stone; an inexpensive mold, consisting of a layer of cement on sand coated with shellac.

U. S. P. 1,042,113/12 Hartung. Process of making artificial stone. Adds much water to gypsum or hydraulic cement, removes excess, dries, colors clods, and remolds.

B. P. 6,597/12 Binetter. In the manufacture of artificial stone for tiles, etc., ground burned clay, such as brick dust, is mixed with 6–8% pulverized vegetable fiber rich in silica such as equisetum "Horsetail"—one-quarter to 1/5 part of hydraulic binding material such as cement is added and the mixture is moistened with dilute hydrofluoric acid of such strength that the silicates are not decomposed. The product is molded and dried and then hardened by treating again with acid.

B. P. 8,399/12 Doggett. An artificial stone made by grinding and mixing together 80% Perrie Le Vaudoné stone, 20% silicate of iron, 2% of a solution of white shellac, 1% of soda and alum, and 15% of Portland cement with the requisite quantity of water.

B. P. 13,564/12 Wartung. In a process of making artificial stone, the binding medium (plaster or hydraulic cement) is mixed with a granular filler (sand, crushed stone, fire-brick, etc.) and excess of water is added. The more soluble impurities are thus separated. The water is decanted and the mass is further dried by pressure in bags.

B. P. 21,161/12 Palmer. A composition for making artificial stone used for walls, floors, columns, etc., consists of cement such as Portland, Roman, Keene's, Parian, or the like, and crushed sea or river shells, excluding shells of pearl-forming mollusks, such as oyster shells. The proportions employed vary from equal parts of the 2 ingredients, to 2 parts of shell to 1 of cement.

B. P. 24,035/12 Boersma. A marine cement for iron concrete construction is made by adding pozzolana in the form of trass or tufa in certain proportions to Portland cement clinker before grinding. The proportions are about 33 parts of tufa to 67 of cement. Gypsum may be added to control the time of setting, and salts such as soda, alum, or the like. Instead of pozzolana, a suitable clay which has been opened up by heating may be used.

B. P. 27,632/12 De Bas. In the manufacture of artificial stone for flooring, a paste consisting of moist colored cement is first placed in the mold and covered with a layer of dry cement and sand. A further moistened mixture of cement and sand is added, and the whole subjected to pressure.

F. P. 17,322/12 Basset. Addition to 455,062. Manufacturing cement or hydraulic lime from gypsum, mixed with clay and coal and treated with steam at 900 deg. C.

F. P. 453,461/12 Jungner. In a process of obtaining alkalies and hydraulic cement from rock materials, pure or iron-containing alkali-aluminum silicates, such as feldspar, micas, clay, schist, are heated to 1350–1400 deg. C., in magnesite retorts, with such excess of lime that, besides the volatilized alkalies, a mixture of calcium silicates and calcium aluminates, having approximately the composition of Portland cement, remains.

F. P. 457,886/12 Pierrard. In the manufacture of hydraulic cement and the like, sulphurized vegetable oils (100 kg. oil with 25 kg. concentrated sulphuric acid) are deacidified by washing with common salt, and neutralized by lime, alumina, zinc, etc., to form soluble salts which combine with the cement mass to form insoluble metal soaps.

F. P. 463,949/12 Duchemin. In the manufacture of light inorganic heat and sound insulating material, plastic materials, such as clay, gypsum, cement, are united with volatile salts such as ammonium sesquicarbonate, and rendered porous by heating to 100 deg. C., under certain conditions being burned.

G. P. 269,181/12 Held. In the production of raised letters, raised surfaces,

and the like, from cement, asbestos, and mica scale, the letters and the like, before the application of the varnish color, are heated in a hydrochloric acid bath.

G. P. 272,371/12 Frank. In the manufacture of artificial stone plates from fibrous materials and hydraulic binding material, the fine asbestos and the cement are intimately mixed in water and poured into a mold. The mass is built up by settling, decanting excess water; pouring, and repeating. When half set it is compressed under 900 atmospheres.

G. P. 284,221/12 Bouvier. Making a hydraulic cement of constant volume by mixing 3 parts of lime and 1 part of clay, sand, acid slags or the like, as powder; adding water and shaping (into building blocks or the like); heating with steam under pressure, and burning at 400–600 deg. C. The product should contain 9% water of hydration.

G. P. 291,070/12 Schoot. The waste gases from Portland cement furnace are freed from the coarser constituents, then cooled and finally conducted into a wide dust chamber which is provided with a hanging filter bag in the upper portion, and discharge at the top.

U. S. P. 1,059,661/13 Edison. Making Portland cement by fusing siliceous and aluminous materials with limestone in such proportions as to secure fusion at a temperature below 1400 deg. C., and produce a liquid non-viscous slag containing about 50% of calcium oxide, treating the fluid slag with a blast to chill and finely subdivide it, adding limestone to make up the desired amount of calcium oxide in the cement and finally calcining the mixture.

U. S. P. 1,073,820/13 Richards. Making iron and Portland cement in a single operation by suitably regulating the charge of the iron reduction furnace.

U. S. P. 1,078,254/13 Carpenter. Method of producing a draft in cement kilns and recovering dust from the waste gases from the kiln by gravity separation and washing.

B. P. 4,679/13 Zerenner. A fireproof composition consists of (1) 40 parts of pumice sand, clinker, coke ashes, infusorial earth, mica, or the like, 40 parts of Portland cement, 10 parts of fiber, 2.5 parts each of casein and glycerol, and 5 parts of gypsum; or (2) 70 parts of pumice sand, etc., and 10 parts each of hydrated lime, fiber and gypsum. In the latter composition 40 parts of cement may be substituted for the lime, the proportion of sand, etc., being reduced to 40 parts.

B. P. 5,976/13 Forder. Destructor residue is crushed, washed, screened to remove iron or steel, and graded; then mixed with best Portland cement, and pure bitumen without flux, to produce a composition for making paving-blocks, damp-courses, etc. It is subjected to heavy pressure while being molded.

B. P. 10,493/13 Moore. Waterproofing and coloring bricks and earthenware by impregnating them with white refined paraffin wax by immersion in a bath of the material at 300 deg. F. When the bricks or earthenware are to be colored, a quantity of fine clear resin is added to the molten wax prior to the addition of an aniline dye or other coloring matter.

B. P. 11,876/13 Elsner. Manufacture of Portland cement from the residue resulting from the burning of household and street refuse, sewage sludge, etc., by the addition, before or after burning, of enriching substances such as lime, clay or silicates and also contact salts, such as alkali chlorides, salts of aluminum and magnesium, calcium chloride, and the like, which bring about a reaction in the heated mixture without sintering or melting.

B. P. 16,636/13 Langlois. A cement is made by intimately mixing natural or artificial Portland cement and powdered rocks, such as feldspar, pegmatite, albite, or granite, singly or combined. The amounts are so calculated that the silica and lime of the product are in the ratio 3:4, while the alumina and lime are 1:1, based on their molecular weights.

B. P. 17,873/13 Basset. In making cement by the action of a reducing agent on a mixture of lime sulphate and clay an excess of reducing agent such as carbon is employed to reduce more of the sulphate to the sulphide than is necessary to react with the remaining sulphate, this excess sulphide being afterward oxidized to the oxide. Suitable proportions are 1580 parts of calcium sulphate, 350 parts of clay, and 125 parts of charcoal.

B. P. 21,579/13 Macdonald. In the manufacture of artificial slate, pulverized materials, such as refuse slate to which may be added sand, powdered brick, stone and coloring matter, are mixed with Portland cement (about 15% or more), and the mixture is moistened with water or a solution of borosilicate. The mass is molded and the articles produced are immersed in a solution of the borosilicate.

B. P. 23,538/13 Basset. In the process of 12,027/12 for making cement by heating plaster with an excess of clay in the presence of coal or charcoal, and then heating the product with limestone, etc., the product obtained by the first heating is mixed with slaked lime to produce a cement analogous to slag cement. In the first heating sulphur may be obtained as a by-product by adding sufficient charcoal to convert into sulphide three-quarters of the sulphate.

C. P. 152,890/13 Ramsey. Producing cementitious products by mixing together ground blast furnace slag, sodium bicarbonate, lime, iron oxide and chrome alum, mixing thoroughly and then placing in a chloride chamber under steam pressure.

F. P. 454,245/13 de Zamboni. In the manufacture of artificial stone, a mass of Portland cement 30, broken marble 40, color 10, and a mixture of alum solution, colophonium, and mica 20, is poured into blocks and before complete hardening (after about 5 hrs.) they are cut into plates, by means of saws.

G. P. 267,125/13 Goppert. Rendering asbestos, cement plates and artificial stone electrically conductive, with a view to applying a galvanic coating, by mixing the asbestos-cement mass employed for the manufacture of the plates with an electric conducting agent, such as graphite or metal powder, which combines therewith and renders the finished product conductive. Also, conducting materials may be compressed with the plates.

G. P. 273,612/13 Hereng. Artificial lithograph stone by compressing cement 3, ground quartz limestone 1, trass 1, and white sand 1 part. Special water treatment is used.

G. P. 274,571/13 Dietz. In the manufacture of a plastic product by mixing cement and impregnated fibrous materials, such as wood, asbestos, and the like, sawdust, wood pulp, or asbestos is heated in a container with 10–15% of paraffin. The impregnated fiber is cooled and mixed with cement and water giving a mass characterized by low density, great permanency, and strength, and which may also be shaped.

G. P. 285,098/13 Bouvier. Addition to 284,221. Constant volume hydraulic lime is made from a pulverulent mixture of lime and siliceous material such as clay, sand, or acid slags, which is treated with steam and then burned at 400-600 deg. C. and ground.

G. P. 291,831/13 Houben. An improved beton for road surfacing is made when 400–500 kg. cement, 600 kg. sand, and 1200 kg. rubblestone are stirred up with water and there is added 80–100 kg. of a fibrous mass which is a mixture of about 6 parts by weight of sawdust to 5 parts of tar and bitumen (10:1). The sawdust can be replaced by cork, leather, or cotton-waste.

Swiss P. 63,045/13 Bar. In the manufacture of non-scaling, fast-colored, dark asbestos cement artificial stone plates, the products made from cement and asbestos are allowed to remain for some time in a metallic salt solution.

Swiss P. 64,425/13 Jungner. In a process for the simultaneous production of hydraulic cement and potassium in free or combined form, the natural potassium-aluminum silicate material, powdered and mixed with potassium-containing material,

is heated until the cement formation is complete, whereupon the potassium is driven off and recovered.

U. S. P. 1,087,098/14 Aylesworth. Making porous artificial stone by adding to Portland cement or plaster of Paris, calcium hydrate and powdered aluminum which react when water is added to the mixture and liberate hydrogen in the mass to increase its bulk and render it porous.

U. S. P. 1,087,914/14 Amies. B. P. 5,242/14 Amies. Cement mixture, for mixing with common earth to form concrete, formed of Portland cement 60, slaked lime 30 and soda ash 10 parts.

U. S. P. 1,088,646/14 Amies. Cement mixture for making concrete by mixing with common soil, composed of Portland cement 50, slaked lime 30 and plaster of Paris 20 parts.

U. S. P. 1,096,705/14 Frood. Making a solid hard brake block by impregnating a thick woven fabric with cement.

U. S. P. 1,100,478/14 Good. Mixture for making artificial stone, formed of sharp sand 48, cement 18, fire-clay 12, and rock salt 1 part.

U. S. P. 1,103,483/14 Capece. Cement for coating wood or making molded articles formed of beeswax 1.8, rosin 4.3 powdered lead 3.15, powdered brick 2.9 and Portland cement 15.1 parts.

U. S. P. 1,105,979/14 Kuhn. Artificial stone formed of plaster of Paris 6, Portland cement 6, magnesite 1, ashes 4, shavings 12 and water 16 parts; for covering boilers, steam pipes, etc.

U. S. P. 1,106,298/14 Gardner. Making colored cement structures by mixing a pigment, e.g., red hematite or ultramarine blue, with a 12% solution of resin soap in water and with about 20 times as much cement, shaping the mixture and allowing it to harden.

U. S. P. 1,112,725/14 Schofer. Making fire-resisting chimney tiles by mixing cement with about 4 times its weight of crushed brick, moistening about 100 parts of this mixture with 6 parts of water, adding 5 parts of alcohol preferably mixed with a small amount of oil, shaping the product in molds and allowing it to set.

U. S. P. 1,117,932/14 Watson. In making putty, a dry powdered mixture is formed of Portland cement with linseed oil and coal tar equal parts; it is prepared for use subsequently by the addition of more linseed oil.

U. S. P. 1,120,632/14 Schlattner. Making "artificial marble" by forming a pulp of water, cement, stone dust, and a soluble fluoride, and adding different coloring materials to different portions of the mixture in a mold to cause it to spread out and form a veined product.

U. S. P. 1,121,532/14 Newberry. Recovering alkalies from the flue gases of cement kilns by leaching the flue dust with water, washing the flue gases with the resulting solution so that it is concentrated by the heat, and then separating the salts by cooling.

B. P. 4,349/14 Houben. A mixture of 400-500 parts of cement, 600 of sand, 1200 of broken stones, and water is mixed with 80–100 parts of a mixture consisting of 6 parts of sawdust and 5 of a mixture of 10 parts of bitumen and 100 of tar. Cork, leather, or cotton may be used in place of sawdust. The product is used for covering large surfaces such as roads.

B. P. 4,928/14 Park. Details of processes for making artificial marble by mixing colored cementitious liquids.

B. P. 13,448/14 Brown. U. S. P. 1,124,238/15 Brown. Making cement and recovering potash from feldspar by mixing the latter with sufficient calcium chloride to furnish chlorine to combine with all the potassium in the feldspar and fusing the mixture with sufficient limestone to bring the lime content of the fused product up to 40–55% (preferably 52%), collecting the volatilized potassium chloride and

combining the residue while still molten with magnesium sulphate solution to improve its cementing properties.

B. P. 13,478/14 Master Builders Co. A cementitious material is made by mixing cement, water and fine iron particles, which are covered with a thin film of magnetic oxide, obtained by crushing cast iron borings and roasting them in air for 5–15 minutes at 700–900 deg. C. The proportions of fresh alkali cement and iron particles may be equal. The cementitious material may be used for bonding new cement to existing cement or concrete structures, and for hardening the surface of concrete.

B. P. 16,530/14 Krupp Akt.-Ges. Portland cement and volatile alkali salts are manufactured from substances containing alkali by burning the ground rock, etc., with lime, limestone, or the like, and a contact salt or salts. Salts are chosen whose bases will become part of the clinker, while the acid radical combines with the alkali and vaporizes with it. Salts of calcium, magnesium, aluminum and iron other than the carbonates may be employed, or they may be formed in the mass by addition of acid. Iron oxide facilitates the reaction.

B. P. 17,756/14 Longan. The free lime present in cements or hydraulic limes is caused to react with a suitable proportion of granite or diorite which has been heated for at least 2 hours, at about 1000 deg. C. and then powdered. A concrete may be made from this cement by adding calcined fragments of similar granite or diorite.

B. P. 17,829/14 Muller. Magnesian cement is made by powdering together burned magnesite and dry, unburned clay or clayey marl, preferably in the proportions of 2 to 1, and adding water before use. A small quantity of powdered potash salt, and fillers, such as sand, sawdust, infusorial earth, cork and leather waste, may also be added.

B. P. 24,761/14 Deckers. A dry mortar or cement is made by grinding quicklime and granular slag together. The lime is slaked by the "hydrate water" from the clay. Continued grinding produces a cement.

G. P. 288,722/14 Perkiewicz. Heat-insulating tubes are made of a mixture of cement 25, brick dust 50, absestos 25 and some graphite made into a plastic mass with water and cast into forms. Instead of cement may be used also hydraulic lime, magnesia with magnesium chloride solution, and the like, and some other mineral fiber may be substituted for asbestos. The product resists sudden heating and cooling.

U. S. P. 1,123,964/15 Warren. Making hydraulic cement by melting a cement rock and slate mixture containing about 50% lime or lime and magnesia, with coke, in an inert or oxidizing atmosphere, breaking up the molten material, spraying it with magnesium sulphate solution and finally grinding the dry product with about 3% of lime sulphate and slaked lime to accelerate the set of the cement.

U. S. P. 1,124,798/15 Peacock. Recovering potassium compounds from fine dust by treating it with a solution of mono-calcium phosphate to react with any potassium silicate present, together with an acid to react with other potassium compounds.

U. S. P. 1,130,143/15 Carlson. Making hydraulic cement by mixing lime with dust collected in the dry-cleaning apparatus for purifying the gases from blast furnaces, the main ingredients of which are lime, alumina and silica.

U. S. P. 1,130,223/15 Wagner. Making artificial stone from a mixture of asbestos fiber 15, ground asbestos 235, grease 16, mussel shells 6, hemp fiber 0.5 and Portland cement 150 parts.

U. S. P. 1,139,934/15 Mollenbruck. Artificial stone slabs are formed of two layers of a mixture of hydraulic cement and fiber. The outer layer is thinner than the main body layer and contains coloring matter, and the two are firmly united and interlocked by fibers which extend from one layer into the other. Limestone or gypsum may be added as fillers.

U. S. P. 1,140,559/15 Atterbury. Artificial stone is formed of asbestos tailings 1 and hydraulic cement 2 parts, with or without sand 2 parts or other filler. Its texture is such that nails or screws may be driven into it.

U. S. P. 1,140,958/15 Cowan. A plastic mixture for coating floors is formed of paper pulp 6 lbs., glue 1 lb., Portland cement 4 lbs., dry coloring 8 oz. and water 2 quarts.

U. S. P. 1,141,610/15 Capece. Artificial stone is formed of beeswax 1.8, rosin 4.3 varnish 0.3, powdered lead 3.15, powdered brick 2.9 and Portland cement 15.1 parts.

U. S. P. 1,143,004/15 Westergard. Artificial stone, tiles, etc., are made by molding a mixture of sand 77, cement 21 and sulphur 2% with soapy water, allowing it to harden slowly, then heating with steam three hours at 42 deg. C., and raising to 100 deg. C. The use of soap gives a product of finer texture, more fire-resistant than if water is used alone.

U. S. P. 1,159,866/15 Plumb. In making fire-resistant building board a layer of loose asbestos fibers mixed with water is placed on one or both surfaces of a sheet of pasty mixture of hydraulic cement and water and the composite sheet thus formed is pressed and heated to 100°.

U. S. P. 1,160,171/15 Heyman. Alkali and cement are made from feldspar and similar minerals. Feldspar, granite, mica or clay, are heated to about 900–1600 deg. with limestone, lime sulphate or marl in such proportions as to give a lime content of 1.7–2.2 times the weight of the argillaceous material in the product. The alkali hydroxide formed is recovered by lixiviation with water and the residue is converted into cement by calcining and grinding.

U. S. P. 1,160,172/15 Heyman. Alkali and cement from feldspar or similar minerals. After heating feldspar, clay, mica or slate, to about 900°–1600° with marl or limestone (without addition of chlorides) the product is lixiviated with water and carbonic acid is passed through the solution. The residue is converted into cement by calcining and grinding.

U. S. P. 1,163,060/15 Atterbury. A building material into which nails or screws may be driven is formed of cement 100, asbestos fibers 23, cinders 160, and sand 133 parts.

Can. P. 163,849/15 Bassett. Manufacture of cement and hydraulic lime from gypsum and clay by decomposing the calcium sulphate by means of an excess of calcium sulphate and subsequently destroying the excess by oxidation.

G. P. 294,539/15 Schott. Salts are recovered from waste gases of cement furnaces by cooling the gases to condense the contained moisture and collecting the dust in a filter bag chamber.

U. S. P. 1,168,046/16 Basset. A mixture of clay, lime sulphate, and coal is heated in a furnace to form cement, and air is injected into the furnace at a point where the temperature is about 900 deg. to oxidize the gases to carbon and sulphur dioxides, the latter being recovered as a by-product.

U. S. P. 1,170,499/16 Kuhn. Artificial stone is made by mixing plaster of Paris 6, Portland cement 6, magnesite 1, ashes 4, wood shavings 12, and water 16 parts.

U. S. P. 1,183,255/16 Toorn. A mixture for building-blocks and other purposes is formed from titaniferous iron oxide, Portland cement, water and an auxiliary binder formed of lime, magnesia, alumina, silica, soda and coloring material.

U. S. P. 1,193,416/16 Owen. Waste slate, partly powdered and partly in coarse granular form, is formed into a plastic mixture with cement and water, pressed into roofing slates, dried in moist air, and hardened by successive treatment with solutions of sodium silicate and calcium chloride.

U. S. P. 1,193,938/16 Solan. "Non-slipping" paving is made of granite grit 400, sand 100–250, cement 300–600 and carborundum 40 parts, mixed with coloring

material such as iron oxide and with water to make a plastic concrete which is allowed to set in the usual manner.

U. S. P. 1,198,816/16 Basset. A mud formed of water, gypsum, coal and clay is heated by waste furnace gases to expel a portion of the water and is then burned to form acid calcium silicate and aluminate and reburned in another furnace with lime to neutralize an acid character of the product and form cement.

U. S. P. 1,198,817/16 Basset. A mixture of clay and calcium sulphate is burned with coal and steam to form hydraulic cement. About 2% of iron oxide is added, as a flux, if not already present in the main ingredients, forming calcium ferrite in the cement.

U. S. P. 1,201,535/16 Wheeler. Substitute for wood in building construction is formed of a fibrous filler, e.g., sawdust and asbestos, mixed with a binder of a soluble silicate and Portland cement or other cements.

U. S. P. 1,204,378/16 Spencer. Cast Portland cement blocks with a highly polished surface resembling marble are formed in a mold with a bottom of glass or other polished material coated with a solution of oxalic acid.

U. S. P. 1,205,482/16 Reid. Brake-shoes are formed of hydraulic cement 70 and sulphur 30 parts to which may be added salt, antimony, mica, iron oxide or asbestos, reinforced with reticulated metal.

U. S. P. 1,209,135/16 Eckel. Potash bearing feldspar and lime or limestones are heated together to a clinkering temperature, in cement-forming proportions and the potash compounds volatilized are collected as dust or fume.

U. S. P. 1,209,219/16 Spencer. Glauconite or similar double silicate is heated with lime or limestone to form cement clinker and fume off potash compounds.

U. S. P. 1,209,220/16 Spencer. A comminuted mixture of nephelite syenite or leucite rock and limestone in proportion to form cement, is calcined in a rotary kiln under condition adapted to fume off alkali, which is collected, and the residue is then clinkered.

U. S. P. 1,239,616/16 Newberry. Dust from cement kilns is molded into small blocks which are re-burned in a vertical kiln with a blast of air under 5–20 lbs. pressure and alkalies are condensed by cooling the gases thus produced.

B. P. 104,595/16 Howells. Artificial stone is made from a mixture of about 4 parts of granite, and 1 part of Portland cement, to which is added about 10% of Bessemer-steel slag.

B. P. 105,054/16 Howells. Slabs and other building units are made of 6 parts breeze and 1 of cement, or 5.5 breeze, 0.5 part granite dust, and 1 of cement.

B. P. 111,686/16 Wheeler. A wood substitute is molded from a mixture of 30 parts by weight of asbestos or sawdust, 10–40 parts of cement such as Portland and 60–30 parts of a soluble silicate.

F. P. 479,752/16 Atterbury. An artificial stone product is composed of cement, asbestos fiber and cinders, and the texture is such that it can be penetrated by nails.

F. P. 479,720/16 Toorn. Construction materials are made of ferro-titanate sand, cement, and water. Oxides of calcium, magnesium, silicon, aluminum or limestone may be added to the sand. Soda is added to promote hardening and increase the strength of the mass.

F. P. 480,285/16 Voisembert. Natural hard stone is pulverized and mixed with feldspar, clay, pulverized glass, quartz, etc., in the proportion of 1–4%, moistened with water, shaped by hydraulic pressure, and heated to a high temperature.

Aust. P. 72,613/16 Massag. In making artificial stone plates a slimed mixture of fibrous materials and hydraulic binders is compressed under at least 300 atmospheres in the chambers of a filter press.

Swiss P. 73,073/16 Golightly. Plates formed from a plastic mixture of cement, asbestos, and water are superimposed with separators between them, and then com-

pressed until all excess water has been expressed, when a powder which sets with water is applied to the edges so that the water cannot penetrate the plates before they have matured. Cement itself may be used for the powder.

Swiss P. 74,200/16 Silber. Dried asbestos plates are combined with cement and a glazing mass is applied and heated to fusion, after which the plates are sprinkled with water.

U. S. P. 1,150,295/17 Newberry. Recovering alkalies from cement kilns, the flue gases are scrubbed with water and the potash salts separated, the insoluble matter being returned to the kiln.

U. S. P. 1,212,840/17 Straub. Molded building blocks are formed of a mixture of cement, water and coal cinder and ashes crushed to pieces not over about 2 cm. and including all the smaller particles of the ash and cinder.

U. S. P. 1,214,725/17 Stevens. Hot gases from the rotary cement-kiln are cooled by a spray of water, the supply of which is changed automatically with the temperature, and suspended matter is separated from the cooled gases in dry condition in a dust separator.

U. S. P. 1,217,335/17 Nesbitt. A waterproof mixture for roofing or other purposes is formed of cement 5, sand 5, ocher 5, white lead 1 part, and sufficient water to produce a plastic mortar.

U. S. P. 1,218,347/17 Woodward. In making concrete, air is driven out of a concrete mixer by steam and the solid ingredients of the concrete are then added while maintaining the steam supply.

U. S. P. 1,219,315/17 Huber. B. P. 110,540/17 Huber. Cement works flue dust is calcined with calcium fluoride and a second flue dust thus formed is collected and treated with water and lime or lime sulphate to recover the fluorine and soluble potash compounds which it contains.

U. S. P. 1,220,735/17 Elsner. Combustion residues of sewage, canal-sludge or similar wastes, which may contain silica 53%, iron and aluminum oxides 23%, lime 15%, sulphur and phosphorus 2% and alkali metal chlorides 5% are mixed with an equal or greater amount of lime and with calcium chloride and heated in contact with steam and air to form a Portland cement.

U. S. P. 1,220,989/17 Huber. B. P. 111,845/17 Huber. Flue dust from cement plants is leached with hot water to prevent the formation of the insoluble double calcium potassium sulphate and to obtain a solution containing potash salts equivalent to 4–5% potassium oxide.

U. S. P. 1,223,834/17 Sanger. Molded building slabs or roofing shingles are formed of a mixture of hydraulic cement 80, fine asbestos fiber 15, chemically active precipitated silica 5 parts and water.

U. S. P. 1,226,292/17 Willing. Molded slabs of concrete for building material are formed of porous granulated slag 4, crushed slag sand 2, and Portland cement 1 part.

U. S. P. 1,226,779/17 Lappen. Fireproof and waterproof building boards are made of a mixture of asbestos fibers 30, hydraulic cement 600, mineral wool from which the fibers have been separated 200 and alum 7 parts.

U. S. P. 1,234,692/17 Ponamski. Artificial-stone slabs are made by treating cotton or other fibrous vegetable material 2–3, with a cold solution of caustic soda or potash and mixing this fiber with asbestos 1–3, cement 100 and water 300–600 parts.

U. S. P. 1,242,236/17 Pontoppida. Slurry for making Portland cement is mixed with sodium carbonate to obtain fluidity with less than the usual water. Caustic soda, common salt, and the hydrate, carbonate, sulphate or nitrate of potassium may be used for the same purpose.

U. S. P. 1,248,455/17 Carson. The plasticity of ordinary ground cement is improved by mixing with it a portion of cement ground to a much greater fineness.

U. S. P. 1,249,708/17 Anderson. The potash in flue dust from cement kilns is rendered more soluble by preliminary treatment with steam.

U. S. P. 1,250,291/17 Ellis. When a potash bearing silicate is to be used in making cement it is first heated with calcium chloride to volatilize part of the potash as chloride. The residue is then mixed with lime or limestone and heated to form cement clinker, while more potash is recovered.

B. P. 104,154/17 Imer-Schneider. Artificial stone slabs, etc., are made of cement 100, water 300-600, asbestos 1–3 parts, and vegetable fibers 2–3 parts. The fiber may be sulphite wood pulp or cotton, which has been treated with a solution of alkali.

B. P. 107,951/17 Kelly. A cement that may be molded or may be rolled like asphalt is made of hydrated Portland cement, water-glass, and an adhesive liquid insoluble in water and not readily saponified, such as oxidized or polymerized oil, with or without a filler.

B. P. 121,986/17 Windsor-Richards. A molding composition is formed of Portland cement 30, waste asbestos or other fiber 15, and clay 10 parts. The clay may be china clay, ball clay, or ordinary clay or fire-clay. Articles molded from the composition may be impregnated with a bituminous liquid as described in 3,364/15.

Can. P. 177,270/17 Huber. The alkali in cement flue dust is recovered as fluoride by heating with alkaline earth fluoride and other material necessary to form a cement.

Can. P. 180,128/17 Nestell. The cement-kiln dust is treated with hot water and carbonic acid (from kiln gases). The free lime is carbonated and the dissolved potash compounds are separated and evaporated to dryness.

F. P. 483,158/17 Wheeler. As a substitute for wood in construction work a fibrous filling is mixed with an agglomerant composed of soluble silicate dissolved in water and cement.

Holl. P. 2,124/17 Krupp. Portland cement is made from alkaliferous rocks by mixing with limestone and the salts of other necessary basic radicals with acid radicals other than carbonic. The resulting mass is sintered in the usual manner.

Swiss P. 74,594/17 Rohr. Sawdust is swollen by means of steam or water to its fullest extent, mixed with cement, and dried. The product is moisture-proof and unaffected by water.

Swiss P. 74,808/17 Zschokke. An anti-rust composition is made by adding to cement a chromate or other substance rendering iron passive. Addition to 62,852.

Swed. P. 41,971/17 Lindgren. Portland cement, powdered stone and water-glass are mixed together, veining material is sprinkled over the mass, the whole is again mixed, and then molded.

Jap. P. 31,541/17 Sayama. Artificial lithographic stone is made when Portland cement is mixed with powdered clay and loess, mixed with water, shaped and finished.

U. S. P. 1,252,264/18 Hambloch. A cement for building purposes is formed by grinding together raw Portland cement clinker and tuff. The cement is resistant to sea water and adapted for ferro-concrete construction.

U. S. P. 1,255,995/18 Eckel. To a cement mixture low in silica, e.g., clay, iron ore or greensand and limestone, there is added diatomaceous earth before burning.

U. S. P. 1,264,009/18 Buttermann. A heat-insulating material for lining cold storagerooms is formed of coal dust 40, sand 25, Portland cement 15, gypsum 10 and blue clay 10 parts, mixed with water.

U. S. P. 1,269,946/18 Madsen. A mixture suitable for use as a plaster, roofing or building-block compound, is formed of cement 4, slaked lime 4 and sand 2 parts mixed with 4 parts of sawdust which has been treated with a liquid formed by boiling together mallows 2, fir needles 1 and eucalyptus gum leaves and bark 4 parts, in water.

U. S. P. 1,274,310/18 Nestell. Dust from coal-fired cement kilns, which contains potash compounds in difficult soluble form, is treated with water at about 100 deg. for several hours to give a solution which when evaporated to dryness is suitable for use as a fertilizer.

U. S. P. 1,274,726/18 McArthur. A plastic composition for making brick, tile or pottery is formed of pulverized tuff 50, sodium silicate 12, salt 2, Portland cement 4 and lime 4 parts.

U. S. P. 1,279,119/18 Jury. A mixture for building purposes that is acid proof, is formed of Portland cement 1, slaked lime 0.1, "sand" obtained from the ashes or clinker of anthracite coal 2, tailings obtained from the same source 3 parts and 20% aqueous soap solution to produce a plastic mixture.

U. S. P. 1,283,188/18 Catlett. A composition to be added to Portland cement to increase its plasticity is formed by the reaction of lime with calcium chloride, with sufficient water to form a plastic mass, and then pulverizing while it still contains water of hydration.

U. S. P. 1,283,483/18 Dwight. Finely powdered fuel is thoroughly mixed with finely divided raw cement material and a thin layer, pervious to air, is covered with a thin layer of slowly burning fuel. This covering is ignited and air is passed through the entire body to cause combustion of the fuel and sintering of the cement-forming materials.

U. S. P. 1,283,261/18 Moon. Cement kiln flue-dust containing difficult soluble potash compounds is heated to just slightly below the sintering point by hot gases free from siliceous ash. A portion of the potash content of the dust is thus volatilized and collected in soluble form. The residue may be leached or used directly as a fertilizer.

U. S. P. 1,286,371/18 McCoy. A dry mixture of sodium or potassium silicate 1–20 and Portland cement 99–80 parts is moistened sufficiently for molding but not enough to dissolve the silicate, it is molded and the article then subjected to the action of steam to indurate the mass. The material thus formed is suitable for use as a binder with various fillers.

U. S. P. 1,287,827/18 Barglebaugh. A concrete mixture is formed of cement 1, ground lava rock (100 mesh) 1.5 and aggregate (about 1 in. diam.) 3 parts. The concrete is relatively light and said to be waterproof.

U. S. P. 1,288,437/18 Merz. Portland cement mill dust is ignited in an oxidizing atmosphere to increase its water soluble potash content. The patent is dedicated to the public for free use.

B. P. 126,472/18 Hadfield. Preparing concrete especially adapted for foundations for rock and asphalt pavings by incorporating with ordinary cement concrete two or more gals. of tar or bituminous mixture such as coal-gas tar or by-product tar, with each cu. yd. of concrete. Alternatively, the cement is entirely omitted from the concrete and pitch-tar or bituminous mixture is added to fill all the spaces in the aggregate.

B. P. 113,758/18 Borch. Portland cement is made from a raw mixture which contains materials having hydraulic properties, such as a mixture of slag and lime, by adding to the slurry a substance which prevents or delays the setting, e.g., 0.25% of cane sugar, hydroxy acid, hydroxy aldehyde or hydroxy ketone.

B. P. 117,460/18 Patentakt. Jungners Kali-cement. Hydraulic cement and alkali are obtained by heating a mixture of alkaliferous silicate and calcareous substance first by means of a fuel to drive off carbon dioxide (900 deg.), and then in an electric furnace to volatilize the alkalies (1400 deg. or higher).

B. P. 117,504/18 Stewart. Concrete of low sp. gr. is formed by using an aggregate made from clay by molding, e.g., in spherical form, burning, glazing, and sprinkling with sand to give a rough surface. These particles, in size ¼ to ¾ inch, are used with sand and lime.

B. P. 121,728/18 Baarnhielm. Ground ashes of burned alum-slate are mixed with Portland cement. The proportion may be of equal parts or the ashes may predominate.

B. P. 121,855/18 Curtis. The dust left after burning iron, copper or arsenical pyrites is used in making an acid-proof composition. The mixture is: sawdust 30%, Portland cement 30%, pyrites residue 30%, whiting 10%. It is moistened and applied as a lining or shaped by molding.

B. P. 122,546/18 Afford. Artificial stone is made by mixing together in a wet state broken freestone, such as Bath or Weldon stone, and Portland cement, and molding the mixture into blocks, etc. A coating of cement may be applied which is subsequently rubbed down.

B. P. 132,356/18 Waine. Powdered hard stone, such as trap, granite, quartz or limestone, is mixed as follows in volume proportions: powdered stone 100, Portland cement 15 to 30, sodium silicate 25, water 75. The mixture is worked into a stiff paste, left to stand for 48 hours and molded.

B. P. 132,593/18 Oilsen. Shale for use in concrete is sintered and then crushed and a mixture of coarse and fine pieces are employed, e.g., 4 parts coarse shale, 2 parts fine shale, 1 part Portland cement, with or without 10% magnesia cement added to the Portland cement, the water used being preferably boiling hot and free from salt or alkali. The proportions may be varied and other ingredients such as Keene's cement, plaster of Paris, or lime may be added.

B. P. 134,598/18 Harland. A concrete is made from a mixture of e.g., 2 parts Portland cement and 1 part of sawdust, made damp with a solution of sodium silicate, and then wetted by adding calcium chloride solution in such quantity as to leave a little silicate in excess.

Can. P. 187,899/18 Viens. A fire-proof, resilient building material is formed of Portland cement, asbestos fiber, slaked lime, sawdust and siliceous material.

F. P. 486,379/18 Henshaw. Potassium fluoride is formed, and sublimed, at a temperature of 950–1000 deg. during the heating of a finely divided feldspathic rock containing calcium fluoride. The solution is converted into the carbonate or sulphate by means of the corresponding alkaline-earth salts.

Nor. P. 28,596/18 Goddard. In making Portland cement gypsum, or the like usual addition, is subjected to a preliminary treatment with tannic acid or tannin.

Swiss P. 78,762/18 Sahli. Composite slabs for paving and the like are formed by making plates from cement, water, and wood, sprinkling a layer of cement and coloring matter over these plates and applying pressure. The form is preferably coated with tar oil before being filled, and tar oil may be added to the mixture.

Swed. P. 43,945/18 Weiler. Artificial stone is made when peat is disintegrated by freezing, mixed with a binder such as cement, and molded.

U. S. P. 1,290,035/19 Anderson. A composition for covering cement surfaces to give uniform finishes is made of zinc oxide 480 lbs., calcined plaster 180, ground asbestos 60, finely ground pumice 150 lbs., "prepared oil" 32 gals., turpentine 5 gals., and naphtha or benzine about 10 gals. The "prepared oil" is made of boiled linseed oil 55, boiled China wood oil 35, litharge drier 20 and naphtha or benzine 90 parts. It is applied with a brush.

U. S. P. 1,296,460/19 Blumenberg. Gases and fumes from cement kilns are treated with a solution of sodium nitrate which forms sodium carbonate, hydrosilicates, potassium nitrate and a small amount of aluminum hydrate and other by-products. Heat renders the silicate insoluble and the soluble salts are leached out and crystallized. Other nitrates might be used instead of sodium nitrate.

U. S. P. 1,296,461/19 Blumenberg. Potassium chloride and sodium carbonate are produced by a method like that of the preceding patent, using sodium chloride in solution instead of a nitrate.

U. S. P. 1,296,463/19 Blumenberg. Recovering potassium compounds by passing

cement-kiln gases through 2 scrubbing towers supplied with water or aqueous mixtures which may contain alkali silicates, or calcium sulphate. Practically all the cement dust, and about half the potash is here collected, the remainder being recovered in 2 other towers with an acid solution or other reagent.

U. S. P. 1,296,464/19 Blumenberg. In charging a cement kiln, 1–2% sodium nitrate is added to the usual constituents to increase the volatility of the potash compounds and facilitate their recovery from the gases.

U. S. P. 1,296,465/19 Blumenberg. Cement-kiln gases are led through a dust-collecting, cooling and expansion chamber and then through a baffle tower wherein they are treated with water or an alkaline aqueous mixture, containing sodium potassium aluminum silicates made by fusing feldspar and sodium chloride, a sulphate of an alkali or alkaline earth metal or sodium nitrate. The wash liquor is circulated until rich in potash and is then evaporated. The gases leaving the baffle tower contain carbon dioxide, nitrogen, a little oxygen and carbon monoxide and some potassium oxide. They are led into a solution of sodium carbonate, forming bicarbonates of sodium and potassium.

U. S. P. 1,296,466/19 Blumenberg. Potassium compounds are recovered from cement kiln gases by first cooling to about 95 deg. and saturating the gases with aqueous vapor, and then cooling to about 5 deg. or lower to separate and collect the potash.

U. S. P. 1,296,467/19 Blumenberg. After hydraulic cement is clinkered (and at any time previous to its final setting), it is treated with ammonium phosphate to form insoluble, neutral and inert compounds of the magnesium, aluminum and iron contents of the cement. Other phosphates and borates also may be used.

U. S. P. 1,296,468/19 Blumenberg. By adding 0.5% or less of copper sulphate to ordinary cement it is rendered harder and stronger. It becomes more resistant to the action of animal and plant life when used for sewer pipes or other underground work. Other toxic salts may be used instead of copper sulphate, e.g., compounds of arsenic, mercury salts or zinc sulphate.

U. S. P. 1,297,638/19 Blumenberg. Potassium sulphate is obtained from waste gases of cement kilns by treatment of the gases with a slurry of water and calcium sulphate, dehydrating the mixture to render the silicates insoluble, leaching with water, and crystallizing the salt from the solution.

U. S. P. 1,298,154/19 Anderson. The potash compounds in cement-kiln dust are converted into soluble form by digesting the dust with water and steam under a pressure of about 200 lbs.

U. S. P. 1,297,297/19 Johnson. Lime and shale containing magnesium are heated separately to 1600–1700 deg., brought together in a highly heated state to form a fused slag, and from this a cement is formed by disintegrating with an air-blast. Ferro-silicon and cyanides of metals such as magnesium or sodium may be formed as by-products from impurities in the raw materials.

U. S. P. 1,297,480/19 Pappen. Cement-fiber board is made by forming a thin wet film of disintegrated mineral fibrous material such as asbestos and mineral wool, sprinkling the surface with dry cement powder and wrapping the film upon itself, e.g., upon the surface of a roll, until a sheet of the desired thickness is obtained.

U. S. P. 1,300,591/19 Ebinger. Artificial stone is formed of crushed crystals of quartz or other material of two contrasting colors, light-colored Portland cement, stearate of lime and coloring matter.

U. S. P. 1,302,452/19 Taylor. A composition for building purposes is formed of cement 96–141, mineral fiber 24–50, sawdust 6–12, and sand 8–16 parts, to which may also be added calcium chloride and magnesia. The mixtures are suitable for making building blocks or for monolithic construction, and will grip metallic fastenings without breaking.

U. S. P. 1,305,522/19 Caven. A mixture suitable for roofing, partitions or insulation is formed by mixing diatomaceous earth 2 parts with sufficient water to

form a plastic mass, burning the material, crushing it and then mixing it with Portland cement 1 part and water.

U. S. P. 1,307,920/19 Nestell. Cement-kiln dust containing potash compounds and free lime is mixed with water, and hot kiln gases containing carbon dioxide are passed through the mixture to increase the solubility of the potash present, to carbonate free lime and to evaporate water.

U. S. P. 1,309,038/19 Light. A concrete suitable for building or paving blocks is formed of sawdust 8, cement 4, plaster of Paris 1 and lime 1 part. Ground corn cobs or other fibrous material may be used instead of sawdust.

U. S. P. 1,309,296/19 Marks. A light concrete having some of the qualities of wood is formed by mixing Portland cement 2 with sawdust 1 part, dampening the mixture with a 25% solution of sodium silicate and then treating it with a 10–20% calcium chloride solution in slightly less than a combining proportion with the silicate.

U. S. P. 1,310,520/19 Bennett. A hard and durable composition for flooring subjected to heavy traffic or for other purposes is composed of Portland cement mixed with 1–2 times its quantity of copper stamp sand or tailing such as may contain: silica 61%, alumina 16%, iron oxide 10%, lime 3.5%, magnesia 1.6%, potassium and sodium oxides 6.3%, copper 0.6% and traces of sulphates and chlorides with loss on ignition of 2%. The mixture is also suitable for making concrete ships.

U. S. P. 1,313,931/19 Walter. In making a porous concrete there is added to the usual ingredients a substance, such as paraffin balls, which is insoluble in water but melts at a temperature which will not injure the concrete. After the concrete has set it is heated or extracted with a solvent to remove the paraffin. The product is suitable for building purposes.

U. S. P. 1,314,772/19 Viens. A resilient fire-proof building material suitable for holding nails is formed of Portland cement 30–65, asbestos 10–55, slaked lime 2–10, sawdust, cork or "rice polishings" 2–10 and sand or diatomaceous earth 2–15%.

U. S. P. 1,315,597/19 Eckert. Cement is mixed with substantially an equal quantity of straw meal to serve as a substitute for sand.

U. S. P. 1,316,071/19 Zukoski. A concrete suitable for roofs, walls or ship hulls is formed by mixing water and cement with pieces of porous material such as pumice stone which are protected from impregnation by the cement and water by limiting the water used. Some sand may be added to the mixture.

U. S. P. 1,317,525/19 Romano. A flooring material is formed of Portland cement 1 mixed with granite dust or flour 2 parts.

U. S. P. 1,319,879/19 Lindley. A flooring is formed of an unyielding base such as concrete, a layer of bituminous cement on the base, a layer of dry felt upon and adhering to the cement, a second layer of bituminous cement on the felt and a surface of sheet rubber over this.

U. S. P. 1,322,893/19 Gaisser. A composition suitable for use as plaster is formed of "superfine cement" 10, slaked lime 4, marble dust 2 parts and water.

U. S. P. 1,323,952/19 Baylor. A cement which has a sufficiently slow initial setting time to permit careful finishing is prepared when natural hydraulic cement 1650 lbs. is ground together with lime 200 lbs. so that 85% will pass through a 100-mesh screen. An amount of water (about 7.5%) is then added to hydrate both the added lime and that which results from the break-up of the calcium aluminates. By this treatment an initial setting time of 5–10 min. may be changed to 4 hrs. or longer and the cement can be reworked at any time up to 9 hrs. without losing any of its final strength.

B. P. 125,979/19 Andouard. Cement and like surfaces are prepared for painting by coating the dried surface first with an acid solution (phosphoric) to neu-

tralize the basic elements in the cement and then with a resinous varnish to isolate on the surface the salts produced by the acid.

B. P. 130,312/19 Naamlooze Asbest-Cement Fabriek. Organic fibers, such as cellulose or animal hair before being mixed with Portland cement for making slabs, etc., are treated with a fluosilicate, sodium silicate, or other salt containing silica with or without other salts or acids.

B. P. 132,247/19 Bayer. An aggregate for a concrete for use in ship-building and for other purposes consists of "moler" diatomite, pumice or like light porous materials, the surfaces of the particles being glazed by heating in a rotating or stationary furnace.

B. P. 135,476/19 Bayer. Pumice-stone is rendered suitable for use in the manufacture of a light concrete for ship-building, etc., by crushing and heating to a temperature of about 100 deg. or higher up to the melting point or it may be heated before crushing.

B. P. 142,958/19 Bravin. A concrete for making building blocks or slabs consists of cement (or lime) 1 measure, breeze or furnace residue, clinker, ashes, etc., 3–4 measures, lime, (or lime-putty) 1 measure, with or without wood sawdust ½–1 measure.

B. P. 143,768/19 deBas. Micaceous iron ore is added to cement, lime or plaster in a moist condition to produce a composition of pleasing appearance. Coloring matter may also be added. The amount used may vary from 1 part ore to 10 parts cement, etc., to a 1:1 mixture.

Can. P. 190,217/19 Night. Concrete is made of finely divided fibrous vegetable material 8 parts, cement 4, plaster of Paris 1 and lime 1.

Can. P. 191,228/19 Jungner. An intimate mixture of an alkali silicate, a calcareous material, and finely divided carbon is heated in the presence of carbon dioxide until the alkali is fumed off. The alkali is recovered and the clinker used for making cement. The finely divided carbon is said to insure complete removal of the alkali metal content.

Can. P. 191,327/19 Huber. A mixture of flue dust, calcareous material and carbonaceous material is heated at least to redness but below the temperature at which large quantities of the potash content are volatilized. The heated mass is then leached.

U. S. P. 1,332,422/20 Boillot. Ground cement-forming materials such as clay and lime or limestone are melted in an electric furnace, to insure uniformity of the product.

U. S. P. 1,333,057/20 Annan. A coating for concrete floors or other similar materials is formed of paraffin 70, beeswax 20, carnauba wax 10 and coloring 8 parts.

U. S. P. 1,334,272/20 Shinn. A hydraulic cement is formed of Portland cement 40–60, mixed with ground slag sand 60–40 parts, with or without slaked lime, 10–30 parts.

U. S. P. 1,344,058/20 Nilsson. A mixture of calcined volcanic ash 70, crushed lava rock 12, water, alum 0.5, Portland cement 7, sawdust 10, alfalfa meal 0.5, oil and tallow or other fatty material, is used for the manufacture of bricks, posts or other building materials, railroad ties, etc.

U. S. P. 1,346,638/20 Crook. A mixture of ingredients such as cement and asbestos for the manufacture of artificial stone is impelled by a blast of water or steam against a moving belt or similarly subjected to a sufficient impact to cause thorough mixing of the materials and the mixture is then compacted into the desired form.

U. S. P. 1,347,869/20 Osborne. A material suitable for roofing and other purposes is formed of particles of asphalt or similar material carrying occluded bubbles

of air, carbon dioxide or other gas and enclosed within a mass of neat Portland cement.

U. S. P. 1,348,099/20 Ellis. The superficial portion of a mass of concrete formed with Portland cement is made with an admixture of copperized granules of iron of 15 to 25 mesh size to harden the surface of the concrete when set. This method is suitable for the construction of floors.

U. S. P. 1,348,775/20 Bellonby. Concrete or similar self-setting plastic material is cured by treatment with steam, then with hot water and finally with hot air.

B. P. 137,330/20 Smidth & Co. Ground "moler" is sintered and mixed with Portland cement in making concrete for ship construction, or for ferro-concrete.

B. P. 137,534/20 Smidth & Co. "Moler" siliceous earth, diatomaceous and infusorial earth, etc., is burned and ground and added to Portland cement to produce a mortar. By employing burned material, larger quantities, e.g., up to 50% by weight of the whole, may be added to the cement.

B. P. 146,172/20 Sining-Larsen. Mortar or cement is rendered porous by the incorporation of a substance which on the addition of water will cause the evolution of hydrogen or another gas. Suitable additions are aluminum, silicon, metalloids, and the like. Hot water may be used and if necessary alkalies or soap solution may be added to increase the reaction.

Jap. P. 35,789/20 Eto. Addition to 29,061. A tile is made of cement 3, sand 2, coal-ash 2.5, pumice stone 2.5, sodium silicate, lime and graphite powder.

REGULATING THE SET OF CEMENT

B. P. 18,345/08 Spackmann. Calcium aluminate or alkali earth compounds rich in alumina are added to lime or other cement materials to increase strength, hydraulic properties, and quickness of set.

F. P. 391,711/08 Grealy. Lime water is used as a retarder to regulate the setting of cement.

B. P. 21,315/10 Durandy. Manufacturing quick-setting composite cement by the addition of a small proportion of ferrous sulphate to Portland cement after burning and before the last grinding.

B. P. 20,076/11 Schallenberg. A composition for hastening the setting of, and for waterproofing, cement or mortar consists of sodium bicarbonate 90, potassium bicarbonate 10, and barium chloride 2 parts, with or without any or all of gypsum or plaster of Paris, soda, water-glass, and potash. About 3 to 10% of this mixture is used, or sometimes as much as 15%.

U. S. P. 1,134,964/15 Strauss. A retarder for plaster is made by concentrating an aqueous extract of lima bean vines and mixing the residue with lime.

U. S. P. 1,214,910/17 Goddard. Portland cement clinker is ground with about 0.8% of gypsum which has been mixed with 16% of tannic acid, to retard setting and increase the water-resisting properties of the cement after setting.

G. P. 293,124/17 Longan. The setting qualities of Portland cement are improved and it is rendered suitable for use in road making and for hydraulic purposes, by adding powdered granite or diorite which has been heated for 2 hrs. at about 1000 deg. C. The active silicic acid is increased, thus insuring the binding of the free lime.

U. S. P. 1,308,644/19 Roll. A retarder for use with plasters or cements is produced by mixing 400 parts of animal substances such as horns, hoofs or hair, with 100 parts of soda or other strong alkali and 200 parts slaked lime in a steam-jacketed digester for several hours to distill off ammonia, then mixing the liquid products formed with 1500 parts of slaked lime, recovering additional ammonia, and drying the product.

U. S. P. 1,308,932/19 Catlett. An oxy-salt, e.g., 1–10% of calcium oxychloride

is used with Portland cement in concrete mixtures to hasten the setting and development of strength. The cement may be mixed dry with the oxychloride or with a sulphate or other oxy-salt having the same function.

U. S. P. 1,320,172/19 Pontoppidan. In making Portland cement, the raw materials are formed into a slurry with water, setting of the ingredients in the slurry being prevented by adding sugar, oxyacids, aldehydes or ketones and the treatment to prevent setting is counteracted in a later stage by applying heat.

U. S. P. 1,355,406/20 Mattison. An asbestos cement structural material composed of Portland cement and ground fibrous serpentine, the latter including microscopic fibers of asbestos and a considerable portion of ground quartz.

J. P. 1,367,984/21 Matsuo. The process of manufacturing cement, consisting of washing sand in hydrochloric acid, adding hot Portland cement clinkers to said sand while still in a wet condition, cooling the mixture and then pulverizing it.

U. S. P. 1,418,160/22 Patee. A building block composed of asbestos aggregate between 5 and 7 parts; Portland cement 1 part; hydrated lime between 10 and 20% of the weight of the cement, the same being mixed with a suitable quantity of water.

WATERPROOFING CEMENT

B. P. 15,100/08 Kathe. Waterproofing and insulating material, made from an emulsion of bitumen, fats, oils, soaps, etc., with clay, cork, saw dust, and mica, etc.

F. P. 396,981/08 Manson. Waterproofing mortar and concrete by means of a product obtained by heating bitumen with manganese dioxide.

U. S. P. 944,233/09 Coleman. A waterproofing composition for concrete wood, etc., is made of gum rubber cement 12.5, turpentine 6.25 and gasoline 81.25 parts.

B. P. 9,381/09 Haddon. Waterproofing compound, for Portland cement. Plastic clay and a sulphate or sulphates and an alkaline substance which will react with the sulphate to form a colloidal precipitate.

U. S. P. 963,810/10 Sala. Permanent, insoluble, incombustible coatings on walls, etc., are produced by applying a solution of potassium silicate with or without a filler, as calcium carbonate, and, after 5–10 minutes when it has filmed and is partially dry, applying a solution of magnesium sulphate to form an insoluble silicate.

B. P. 19,714/10 Blackman. Waterproofing composition for artificial stone, brick, wood, stucco, plaster cast, etc., consisting of ozokerite or other mineral wax, mineral oil, steatite and a solvent such as a light hydrocarbon.

B. P. 23,354/10 Colletas. A waterproof coating for buildings made of damp materials, is composed of ozokerite 10 parts dissolved in white-spirit 90 parts. Ordinary paints may be applied over this coating.

B. P. 27,130/10 Rauhoff. Cement or concrete products are rendered waterproof by the addition of an oxidizable substance such as iron in the form of very fine powder and asbestos.

B. P. 28,284/10 Hemingway. Natural or artificial stone is hardened by treatment with arsenic acid and a soluble silicate.

B. P. 30,091/10 Krumpelmann. Manufacturing a substance for waterproofing cement by treating of bituminous shale with hydrochloric acid and drying the product to a powder.

G. P. 230,527/10 Wunderlich. In the manufacture of mortar the product is rendered quite impervious to water by saturating the constituents of the mixture (pumice stone, granulated slag, ashes, crushed bricks), with soap solutions, and then drying.

G. P. 242,454/10 Mecke. Waterproofing cement, etc., with the use of ammonium oleate.

U. S. P. 996,042/11 Moore. Waterproofing concrete walls (e.g. tunnel tubes under water) by first clearing the concrete of water with a jet of compressed gas,

then introducing a waterproofing liquid under pressure, and maintaining a gaseous pressure against the concrete until liquid has had time to act, to prevent reinfiltration of water.

U. S. P. 999,493/11 Ellis. Waterproofing concrete by impregnating and coating the exposed surface with pontianac rubber resin and a pigment.

U. S. P. 999,708/11 Ellis. Composition for waterproofing concrete, consisting of pontianac rubber resin, which has been heated to 500 to 600 deg. C. until it has lost about 20% in weight, thinned with a volatile liquid (benzol or benzine) to which 5 to 10% of aluminum soap of Chinese wood oil or 2 to 3% ceresin wax may be added.

B. P. 2,703/11 Casteleyn. Waterproofing composition for cement or mortar consisting of wood, creosote, pitch, coal or coke, tar, and caustic soda.

B. P. 26,941/11 Spooner. Waterproofing cement substances, bricks, stone, etc., by applying to them a thin layer of wood-tar creosote and pigment at normal temperature.

G. P. 248,297/11 Mecke. Addition to 242,454. Process of rendering cement bodies waterproof. According to the principal patent a solution of ammonium sulpho-oleate, without or with hydrocarbons, is used. The additional patent covers the addition of fillers such as clay, magnesite, salt and hydroxides, of the alkaline earths.

G. P. 271,247/11 Borsari. Lining cement vats with 2 intimately united layers of material, the layer next to the cement wall being alkali-proof, while the inner layer is acid-proof. The alkali-proof layer is a mixture of asphalt, gutta-percha, and wool fat freed by means of caustic soda from saponifiable matter, to which talcum is added as a filler. An acid-proof layer which unites well with this is made by mixing together Manila copal wood pitch, freed from its low melting constitutents, and thickened linseed oil, with talcum as a filler.

U. S. P. 1,021,569/12 Bladen. Composition for waterproofing concrete. A solution of nitrocellulose, tung oil acid, and sandarac resin.

U. S. P. 1,023,926/12 Dieckmann. Composition for waterproofing cement: caustic alkali, fish oil, alum, lime.

U. S. P. 1,036,898/12 Plumb. Waterproofing cement mixtures with insoluble soap, mixed with ammonia and water.

U. S. P. 1,031,003/12 Horn. Concrete waterproofing composition containing calcium soap of tung oil.

U. S. P. 1,048,695/12 Horn. Composition for waterproofing concrete, containing Chinese wood oil, calcium stearate, casein, a preservative and water.

B. P. 17,070/12 Plumb. Waterproofing cement, mortar, and concrete by adding to the gaging water an insoluble soap mixed with 1–5% of aqueous ammonia to render the soap readily miscible with water. The ammonia is subsequently evaporated.

F. P. 452,185/12 Mijs. Process of rendering concrete impermeable to mineral oil by applying to its surface a hot mixture of gelatine glue and glycerol and then fixing with formol.

U. S. P. 1,073,129/13 Horn. Waterproofing concrete by superficial treatment with aluminum stearate and tungate.

U. S. P. 1,074,364/13 Horn. Plastic troweling waterproof cement mixture, made by melting copal or asphalt, adding Chinese wood oil, then adding an aqueous paste of ammonium stearate and a filler, e.g., barium sulphate, calcium carbonate, calcium hydroxide or Portland cement.

U. S. P. 1,075,097/13 Forni. Composition for waterproofing cement mixtures, composed of calcium oxide 100, linseed oil 70, water sufficient to slake the lime, and sulphur 25.

U. S. P. 1,076,028/13 Ellis. Waterproofing cement by passing the finely ground cement through a spray of molten waterproofing material, e.g., paraffin.

U. S. P. 1,077,689/13 Ellis. Concrete-waterproofing mixture prepared from over-neutralized acid sludge from petroleum refining, combined with lime and fuller's earth or other filler.

U. S. P. 1,080,632/13 Horn. Waterproof troweling cement mixture formed by melting a varnish gum such as kauri 20, mixing with a drying oil, e.g., Chinese wood oil 70, and a fatty acid, e.g., acids from fish oil 10, adding hydrated ammonium stearate 40, and then adding slaked lime or Portland cement 70 parts to form a water insoluble soap, the complete mixture being combined, if desired, with a filler such as talc, soapstone, barytes or kaolin.

U. S. P. 1,081,155/13 Schuler. Making a waterproof Portland cement mixture by mixing alum 3, potash soap 3, pozzolana cement 28 and slaked lime 24 parts with 200 parts Portland cement.

B. P. 5,908/13 Hill. In the manufacture of a Portland cement, magnesium silicate, e.g., in the form of soapstone (1 to 10%) is added to render it waterproof.

B. P. 26,079/13 Finkler. A waterproof covering for walls, plaster, etc., to remove dampness and to neutralize the action of hygroscopic salts, consists of celluloid dissolved in acetone or wood spirit, vegetable tar (resini pini) and colophony dissolved in ether, and white manganese (the borate).

B. P. 27,128/13 Caudemberg. Plastic compositions are obtained by distilling gas tar to remove benzene, etc., mixing it with one-third its weight of a solution of India rubber in a mixture of equal parts of benzene and carbon bisulphide (the solution being 1 part rubber to 10 of benzene and 10 of bisulphide), mixing this liquefied mastic at about 100° C. with cement, as follows: mastic 10, sand 38, tarred or dried gravel 24, and Portland cement 25. The material is used for roofs, terraces, paving, walls, bricks, and for damp-proofing and sanitary purposes.

F. P. 453,751/13 Hansen. In the manufacture of impervious cement, fish train 40 kg. is cooked with hydrochloric acid 10 kg. and added hot to a slaking mixture of lime 200 kg. and water 300 liters, the sludge being dried, and added to the cement mass in the proportion of 3–4%, and the whole ground.

F. P. 454,895/13 Kuthemann. In the manufacture of a binding and waterproofing material for walls, tar 100 kg. is clarified by the addition of paraffin 3 kg., linseed oil 5 kg. is added, and the mass is boiled strongly. For use, the heated mass is mixed with siccative 6 liters.

G. P. 284,925/13 Frank. As a waterproof dressing for artificial stone and concrete a mortar containing small fragments of asphalt is applied, the surface layer is removed, and the exposed asphalt particles are softened by ethereal oils or by heat, and allowed to flow together, or they may serve as a key for a layer of asphalt.

G. P. 289,122/13 Saces. Artificial stone slabs are waterproofed by spraying with water-glass solution which contains finely pulverized mineral matter, such as alkaline earth carbonates and coloring oxides. The slabs are heated to coagulate the silicic acid, washed in water, and immersed in a weak acid bath. The acid may be hydrofluoric, hydrofluosilicic, sulphuric, or their aluminum salts. A surface of transparent colloidal silicic acid is obtained, permanent in cold and warm water, and weather-proof.

A. P. 3,034/13 Girzik. In a process of waterproofing articles by impregnation with solutions of cellulose compounds and castor oil, stearic acid is added with a view to removing the adhesive properties, and increasing the water resistance of the impregnation.

U. S. P. 1,082,035/13 Markus. Waterproofing mortar by adding to it a mixture formed from sodium oleate, a soluble aluminate, calcium hydrate and pulverized clay.

U. S. P. 1,085,227/14 Seaman. Removing moisture from artificial stone and rendering it non-porous by treating its surface with a solution of stearic acid 1 in alcohol 16 parts.

U. S. P. 1,088,022/14 Horn. Waterproofing concrete by mixing ammonium stearate with it.

U. S. P. 1,098,723/14 Hamlin. Waterproofing brick or stone walls with an adhesive solution, e.g., varnish sizing, and then applying to the coated wall a blast of finely divided stone which has been coated with a rubber solution, or other transparent waterproof material.

U. S. P. 1,099,974/14 Ellis. Mixture for waterproofing cement and controlling its setting, containing equal parts of basic calcium stearate and sodium aluminate.

U. S. P. 1,104,782/14 Craig. A mixture for waterproofing walls is formed of powdered mineral wax 1, Portland cement 4, sodium chloride 2, saturated aqueous solution of sodium carbonate 4, and water 28 parts.

U. S. P. 1,109,120/14 Ellis. Waterproofing concrete by adding to it a mixture formed from mineral oil 10, potassium oleate 1, potassium resinate 1, heavy pine oil 2 and coal tar or asphalt oil 2 parts.

U. S. P. 1,109,540/14 Olson. Mixture for waterproofing concrete, formed of lime 10 lbs., crude oil 1 gal., and water.

U. S. P. 1,109,799/14 Snyder. A solution for waterproofing cement, concrete, wood or cloth is formed from sodium hydroxide 1.2–3.7 lbs., Japan wax 20–28 lbs., sulphur 8 oz., glue 20–24 lbs., alum 3–16 lbs. and potassium nitrate 2–4 lbs., with sufficient water to make 100 gals.

B. P. 4,805/14 Abraham. In the process, described in 10,478/12 of waterproofing soil or rock by the injection of 2 substances (e.g. aluminum sulphate and sodium carbonate) which form in the pores an insoluble precipitate of large specific volume, a neutral liquid, preferably water, is injected between the injections of the two chemicals.

B. P. 10,491/14 Heide. U. S. P. 1,177,156/16 Heide. Waterproofing stone, plaster, fibrous insulating-materials, etc., by means of a solution formed by mixing an ammoniacal or alkaline solution of the hydroxides of such metals as zinc, copper, lead, tin, chromium or aluminum with a solution of soap.

B. P. 13,542/14 Goddard. In making a Portland cement that is waterproof, there is mixed 1 part of tannic acid or tannin to 5 parts of gypsum, and 0.8 part of treated gypsum to 100 parts of clinker, and the mixture is ground.

C. P. 156,392/14 Secord. A waterproofing composition for cement comprising caustic alkali, alum and hydrated lime.

F. P. 19,612/14 Houben. Addition to 466,878. An elastic impermeable concrete, is made by mixing with the concrete while in a pasty state, material such as sawdust saturated with tar.

G. P. 282,368/14 Fleisch. A slaked lime, smooth in texture and moisture-proof is made with the aid of beef tallow and a carbohydrate. The lime is slaked by boiling water and intimately mixed with beef tallow, with the addition of crystallized sugar.

G. P. 286,768/14 Heide. Addition to 285,967. Stone, etc., are rendered water proof according to the early patent by spraying with ammoniacal zinc solution and soap. It is now shown that instead of zinc, the hydroxides of copper, lead, tin, chromium or aluminum may be used.

U. S. P. 1,128,696/15 Levi. A waterproofing material for concrete is made by dissolving 30 parts of resin in a water solution of soda, adding 70 parts of soap and 5 parts of Carnauba wax, then adding calcium chloride, and washing, drying and pulverizing the precipitate formed.

U. S. P. 1,141,848/15 Stehm. A mixture for waterproofing cement, concrete, etc., is formed of kerosene 60 gals., spermaceti 10 lbs., and cottonseed oil 2.5 gals. thoroughly mixed at a temperature above 80 degrees. This mixture is added to about 12 times its weight of water used in wetting the cement or concrete.

G. P. 293,715/15 Giese. When 2.5% of alkali silicate and 2.5% calcium chloride

or carbonate are added to the clinker while grinding, a product is obtained that is only 1/10 as permeable as ordinary cement and of greater strength.

U. S. P. 1,189,549/16 Ellis. A composition for protecting structural steel imbedded in concrete is formed of a mixture of Pontianak rubber resin 25, guayule rubber resin 50, benzol 50 and Portland cement 50 parts, and is used for coating the steel.

U. S. P. 1,189,550/16 Ellis. Priming coating for use on concrete is made of vulcanized Chinese wood oil mixed with Jelutong or Pontianak resin, a thinner such as benzol and gasoline and, if desired, with rubber, vulcanized cottonseed oil, tar, gilsonite or pigments.

U. S. P. 1,189,551/16 Ellis. A waterproof coating for use on concrete is formed of a cold-cut saturated solution of Jelutong or Pontianak rubber resin in a hydrocarbon solvent, such as benzol; 3 parts is mixed with Chinese wood oil 1 and Japan drier 0.12 part.

U. S. P. 1,197,107/16 Craig. In waterproofing articles of clay or cement aluminum oleate is treated with carbon dioxide under pressure to form aluminum which on exposure to the air is converted into oxide. The patent also describes hardening of zinc, barium, or silica paints by use of carbon dioxide.

U. S. P. 1,205,735/16 Hansen. For waterproofing cement a warm mixture formed of fish oil 40 and muriatic acid 10 parts (boiled together) is mixed with lime while being slaked in water 300 parts, the paste thus formed is allowed to dry and added to about 25–35 times its weight of cement clinker and the product is finely ground.

B. P. 100,886/16 Morikami. A powder for mixing with cement, concrete, and mortar to make them water-tight, consists of a mixture of calcium soap and powdered burned alum. The calcium soap is made by boiling a fatty or resinous soda soap with milk of lime. The product is skimmed off, dried, and powdered, and 100 parts are mixed with 10 parts of burned alum.

B. P. 105,087/16 Plant. Cement and concrete are waterproofed by adding a mixture consisting of 2 oz. each of Russian tallow, mutton fat, and lampblack, 4 oz. of shellac spirit varnish, and 2 lbs. of whiting mixed with water.

F. P. 480,507/16 Jacobs. A protective coating for iron, wood, metals, cement, etc., is made when calcined shell lime which has been exposed to the air is mixed with a dry bituminous material such as asphalt, bitumen, coal tar, petroleum, bitumen mastic, etc.

B. P. 1,396,546/21 Badder. A mixture for waterproofing cement comprising aluminum silicate saturated with a solution of a silicate of a metal and dried, and aluminum silicate saturated with a solution of an alkaline earth metal chlorid and dried.

VARIOUS COMPOSITIONS WITH CALCAREOUS BASE OTHER THAN GYPSUM

G. P. 216,605/08 Heinrichsdorf. Plastic mass. Heating slaked lime with linseed oil and adding wood tar and alcohol.

G. P. 217,449/08 Stahl. Plaster and polishing stones. Calcium oxide or calcium-magnesium oxide pressed into forms and dipped in paraffin or other waterproof substance.

G. P. 229,010/08 Rawitzer. Manufacture of artificial stone by mixing powdered burned or slaked lime with carbon dioxide and allowing the material to solidify in forms.

G. P. 233,877/08 and 234,367/08 Spackmann. Lime mortar for plastering and building purposes, composed of lime with the addition of calcium aluminate.

U. S. P. 942,505/09 Kirkham. A composition for railway ties, etc., is made of

lime rock 60, kaolin 20, silica grit 5–15, pulp fiber 12 and asphaltum or tar (combined with 10% sulphur) 8 parts.

B. P. 29,691/09 Class. In agglomerating substances in the form of small fragments of dust, the substance, mixed with lime and water, is placed in a receptacle which is first evacuated and then filled with carbon dioxide; the vacuum is established quickly in order to cause the mass to become porous.

G. P. 229,011/09 Rawitzer. Addition to 229,010, similar to the preceding, with the addition of water.

B. P. 11,242/10 Barrett. In the manufacture of building stone by mixing crushed waste material with lime and afterwards pressing and carbonating the mass, the lime is hydrated and reduced to the consistency of cream before incorporation with the waste material, and after immediate pressing and drying is carbonated with warm, moist carbon dioxide.

B. P. 11,926/10 Mendez. A composition for use as building material, paint, etc., composed of sulphide of iron (e.g. pyrites), powdered and made into a semi-liquid mass with a suitable calcareous or argillaceous binder.

G. P. 243,230/10 Gunther. Manufacturing plaster from granite and the like, by finely grinding 80 parts of granite with 20 parts of gypsum, and adding granite chips, sand and lime.

Ger. 250,962/10 Kapferer. In the manufacture of a waterproof slaked lime by adding fat and oil, the fatty substances are dissolved in an organic solvent such as alcohol or acetone and added to the slaked lime. The fluidity of the mass is increased by the addition of starch or high molecular substances in pulverulent form.

A. P. 2,737/10 and A. P. 437/11 Emele. In the manufacture of dry magnesia cement or of waterproof artificial stone, burned magnesite or burned dolomite with or without the addition of lime or burned gypsum is worked up together with alum or sulphate of alumina.

U. S. P. 994,496/11 Berrigan. Molding plastic material, for making reinforced tubing for example, by feeding a fluent mass of material containing a calcareous cement, water and a filler, such as sand, upon the inner surface of a centrifugal drum, and gradually extending the material from the point of first application.

B. P. 9,272/11 Julians. In the manufacture of artificial stone the lime is first mixed with a small portion of the finely crushed stone or slag and the mixture is then slaked, whereupon the remainder of the stone is added. The product is rapidly mixed to cream-like consistency, pressed and carbonated.

G. P. 237,938/11 Technische Bureaux. In the hardening of objects formed from calcareous sand, steam is economized by preheating to 100 deg. C. with exhaust steam from an engine, and then employing high pressure steam at 170 to 180 deg. C.

G. P. 247,577/11 Technische Bureaux. In the manufacture of lime sandstone articles impervious to water, impregnating the surface with oil which is introduced with the steam during the hardening process.

G. P. 249,910/11 Weisflog and B. P. 7,067/12 Weisflog. Cement for building up lithographic stones from fragments, consisting of sodium silicate, calcium carbonate, burned magnesia, and zinc dust.

G. P. 250,237/11 Rothenberg. In the manufacture of lithographic stones, artificial limestone, prepared by hardening slaked lime with carbon dioxide is treated with colloidal binding agents to reduce porosity.

U. S. P. 1,045,933/12 Belknap. Porous heat-insulating material formed from diatomite, lime and asbestos, a portion at least of the lime combined with the diatomite as silicate.

B. P. 11,799/12 Billwiller. Dolomite calcined at about 850° C. is mixed with a solution of water glass to make a mortar for the manufacture of artificial stone. Small quantities of gypsum and clay may be added, and also sawdust, asbestos or cork meal. The stone is hardened by treatment with alkali phosphate solution.

B. P. 19,911/12 Von Staszewski. Calcining limestone containing a low per cent of calcium carbonate in a rotary kiln of the kind through which the materials and the heating gases are passed in the same direction. The calcined product is slaked, if necessary, ground with 2% of plaster of Paris, and then made up into mortar in the usual way.

F. P. 452,399/12 Carlson. In the manufacture of a special cement, filtered blast furnace flue dust (10 to 30%) is ground with powdered slate lime (90 to 70%) or also with Portland cement, hydraulic lime, etc.

F. P. 452,719/12 Gourion. In the manufacture of artificial stone masses, unslaked fat lime 200 lbs., is mixed with marl or refractory red sand 779 lbs., moistened with a solution of alum 1 lb., and gypsum 20 lbs., in water, solidified under high pressure, immersed in water and finally dried. Product is hard and takes a high polish.

F. P. 460,438/12 Maguin. Working bone slime of sugar manufacture into cement, in view of the fine division of the calcium carbonate. From 9,000 parts bone slime or 4,000 parts dry material, with 1,100 parts dry clay, about 3,160 parts cement are produced.

G. P. 270,516/12 Czarnikow. In the manufacture of mortar from lime and sand, whereby the lime is slaked in the presence of the sand, with heating, the hardening property of the product is improved by adding cryolite or a mixture of sodium fluoride and aluminum sulphate. The cryolite decomposes, disintegrates the sand, and forms calcium-aluminate. Hydraulic properties are also imparted.

G. P. 273,877/12 Becher. In the manufacture of a non-spotting hydraulic cement, lime is slaked, with heat, in the presence of sand and barium fluoride. By this means the soluble sulphates of the cement (made of lime, sand, broken stone, and water) are rendered harmless and silica in the sand is attacked.

G. P. 287,075/12 Armstrong. A heat insulating product is made by steaming a mixture of infusorial earth 75 parts, slaked lime 12.5, asbestos fiber 12.5 parts, and water to allow pouring.

B. P. 22,297/13 Douzal. Artificial marble is made by adding a mineral hydrocarbon, such as vaseline oil, to a plastic mass composed preferably of calcium carbonate and a mixture of a halide and oxide or basic halide of a metal such as calcium, barium or zinc. Lead acetate solution is added to the mixture. An example is: 100 parts of chloride, 500 of oxide, 150 of water, 75 of vaseline oil, 95 of calcium carbonate and 60 of lead acetate.

F. P. 455,547/13 Floeh. In the manufacture of artificial marble, ground white marble is mixed with colors and sifted in layers into tight containers, moistened with water and compressed.

F. P. 457,145/13 Rodman. In the manufacture of cement masses, pulverulent materials, such as coke (100 kg.), are combined with alkalies, such as soda (10 kg), together with chalk (20 kg.), also molasses water and, after passing through a 6 mm. sieve, are rolled into balls, in such manner that by merely heating, the balls harden interiorly, and do not adhere to one another.

F. P. 457,664/13 Kaye. In the manufacture of artificial stone, a portion of the siliceous material, such as sand, is combined with slaked lime, set by artificial heat, and ground.

G. P. 293,415/13 Joliet. Dry lime and sand mortar is improved by spraying the finished mortar with water-glass solution or with slimes of slag powder, pozzolana, trass, or siliceous matter in milk of lime, alkali, soap, or water-glass solution.

U. S. P. 1,095,180/14 Carson. Making cement by pugging clay with water, slaking lime in the mixture, roasting the product at a temperature of 315-425 deg. C. and grinding.

U. S. P. 1,096,384/14 Morris. Cement for making artificial stone, formed of magnesia 3 and slaked lime 1 part.

U. S. P. 1,107,431/14 Malinoszky. Making building blocks by mixing sand 50–75% granite 10–30% and lime 6–15%, wetting the mixture to render it plastic, molding, steaming and saturating with a solution of sodium silicate and sodium chloride.

B. P. 7,954/14 Denny. Composition for coating ships' decks, floors, etc., consists of a mixture of 100 parts of gypsum cement, 15 of Portland cement, 20 of pumice, and 20 of sawdust, made into a stiff paste with a 2% solution of sodium aluminate or with water. Other filling materials, like coke breeze, asbestos, etc., are used. The term "gypsum cement" does not include plaster of Paris, stucco, or like hydrated sulphates.

B. P. 17,686/14 Walker. A composition consisting of 60–80 parts of prepared chalk, 10–30 parts of vaseline, 1–5 parts of castor oil, and 1–5 parts of iron oxide paint, is employed for making water-tight the joints of covers of boxes for underground electric mains and distributors and of other boxes in exposed positions.

B. P. 24,266/14 Eaton. A mixture of calcium carbonate (chalk) 1.98–12.5% of calcium phosphate (powdered bones) and 0.02–1.5% of silica (sand), together with a suitable binder, is used for forming dolls' heads, etc. Suitable binders are (1) a mixture of 1 quart of glue solution, 1 teaspoonful of Venice turpentine, and 1 pint of a strong solution of alum, or (2) a mixture of a solution of casein, water-glass, and gum arabic.

G. P. 292,561/14 Olschewsky. In lime mortar, to fill the spaces between the sand without increasing the lime content or appreciably changing the weight, paper stock as it comes from the hollander is added to the lime slurry.

U. S. 1,124,045/15 Lobert. A material for making molded pipes and railroad ties is formed of rock asphaltum 2, karl asphaltum 2, marl 30, asbestos 1, sulphur 1, common salt 2 and seaweed 4 parts.

U. S. P. 1,142,989/15 Spackman. Hydrated lime plaster is made by crushing together a mixture of 85 parts of hydrated high-calcium lime, containing about 5% of unhydrated lime, 10–15 parts of a fused calcium aluminate mixture containing a low per cent of lime and about 12% of sodium or potassium-bisulphate.

B. P. 4,700/15 Lizieri. A mixture of 2 parts each of asbestos fiber and finely ground pumice with 1 part of gypsum cement is used for covering ships' galleys, bulkheads, etc. It may be applied in the plastic state or as slabs.

U. S. P. 1,171,676/16 Sutcliffe. Molten slag is granulated in a thick mixture of slaked lime and water, drained, dried and compressed.

U. S. P. 1,188,759/16 Guay. A wet mixture of silica 85–95% and slaked lime 5–15% is molded into bricks and the latter are indurated by action of steam under 150 lbs. pressure while covered with a layer of sand to protect them from direct contact with the steam and avoid warping or cracking.

U. S. P. 1,204,085–6/16 Sutcliffe. Tough roofing material is formed of lime, fine sand and asbestos.

F. P. 480,407/16 Quillet. Artificial sandstone pipes are made of a mixture of 6–10 parts of lime to 100 parts of fine sand, and 7–10% water. The lime is permitted to slake, the mass is compressed in molds, and the pipes are then heated in an autoclave under 8–10 atmospheres.

U. S. P. 1,230,032/16 Noll. A mixture for making plaster is formed of slaked lime 15, yellow clay 20, silica sand 60, and rye flour 5 parts.

U. S. P. 1,241,211/16 Hay. Plaster or mortar is made by adding water to aged lime putty to form a thin paste which is beaten to aerate it and mixed with sand, hardening material such as Keen's cement, and shredded strands of old rope or other fibrous material which are blown into the mixture.

Norw. P. 26,994/16 Gresly. Slow-setting hydraulic cement without alumina is obtained by burning and grinding silica, lime, and calcium sulphate.

S. P. 40,415/16 Gresly. Hydraulic cement is formed when an intimate mix-

ture of calcium silicate and iron oxide, with calcium silicate alone, is heated and suddenly cooled, calcined lime added, and the whole burned to sintering with the addition of calcium sulphate, finally pulverizing the product.

U. S. P. 1,234,306/17 Dlmke. A cement for stonework is formed of whiting 30, ground white lead 20, ground stone 10, varnish 25, linseed oil 10, water and a mineral coloring material 3 parts.

U. S. P. 1,235,766/17 Charlton. In making sand-lime bricks lime is digested with 5 times its weight of water under steam at 225 lbs. and the product is filtered and dried to obtain two molecules of lime to one of water. This is mixed with sand, compressed into bricks and these are steamed under 100–135 lbs. pressure for 8–12 hours.

U. S. P. 1,223,239/17 Becker. In making mortar from lime or cement, sand and water, lead acetate is added in an amount at least equal to 0.5% by weight of the lime or cement used, to render the product more coherent and resistant to sea water. Litharge also may be added.

U. S. P. 1,228,486/17 Siegle. Heat insulating material is made from a mixture of limestone particles and hard soap (calcium or magnesium). Asbestos or sulphite cellulose fibers or both may be mixed in.

Can. P. 177,836/17 Parker. Silica, clay and shale with limestone as a binding agent are calcined together in proper proportions for molding in the cold when moistened.

G. P. 318,699/17 Klemment. A coating material is made of burned lime 10 kg. stirred with water 2 kg. to complete hydration, by adding to the heated mixture 2 kg. of cold tar and stirring until a dry homogeneous product is obtained. It is prepared for use by diluting with cold water.

U. S. P. 1,289,862/18 Mitchell. Dolomite is crushed and heated sufficiently to dehydrate it, and then mixed with sulphur and paraffin 2% while hot and cast in a mold under pressure to form an insulating or building material.

U. S. P. 1,284,505/18 Warner. Lime containing magnesia is first mixed with sufficient water to hydrate the lime while under atmospheric pressure and the hydration of the magnesia is afterward effected in a closed vessel under pressure. This treatment produces a material which forms readily worked mortars of good strength.

B. P. 133,705/19 Iwersen. Artificial marble is made from a mixture of cement, crushed or pulverized marble, fragments of marble, olive or other soft oil and colors. The product is dried by air or heat.

B. P. 133,745/18 Alexander. Sand-lime bricks, blocks, tiles, etc., are hardened by exposing them to super-heated steam at a pressure of 5–10 lbs. above atmospheric pressure in hardening chambers made of ferro concrete or the like, which may be erected *in situ*.

U. S. P. 1,302,260/19 White. A material for lathing is produced by consolidating a hot mixture of stone-forming materials such as calcium carbonate and sodium silicate with a body of paper or other fibrous material, by atomization.

U. S. P. 1,308,136/19 Wood. A paste calcimine is formed of whiting 350 lbs., water 11 gals., and 94 lbs. of a vegetable glue containing the reaction products of starch, water, caustic soda, resin size and acid.

U. S P. 1,317,680/19 Bickel. A mixture suitable for wall plaster is formed of lime 99, aluminum sulphate 1 part, a filler such as sand and the necessary water.

U. S. P. 1,318,922/19 Rhodes. Dry pulverulent hydrated lime is freed from air and allowed to settle into a compacted mass to reduce its water absorption capacity and render it capable of giving greater plasticity to mortars and plasters.

U. S. P. 1,319,918/19 Zimmer. A mixture for making compressible artificial stone is formed of powdered limestone, a bituminous substance such as asphalt or

oil residues and an emulsifying agent such as sulphonated sebacic acid. The product is suitable for road-making.

U. S P. 1,320,672/19 Black. A paving composition is formed by mixing disintegrated limestone with an adhesive and waterproofing binder such as asphalt, in vacuo, using just sufficient binder (11–19%) to fill the pores of the material.

U. S. P. 1,323,597/19 King. A cement suitable for repair work on wood, marble or slate is formed of resin 40 lbs., whiting 60 lbs., paraffin 2 lbs., and linseed oil 500 drops. The cement will set within a comparatively short time and may afterward be softened by heating and when cooled will set again.

U. S. P. 1,327,145/20 Charlton. A cement of a greenish or brownish white color is obtained by digesting greensand with lime. When freshly made the material is a plastic self-hardening mass containing silicates of calcium, iron and aluminum and when treated with steam it undergoes a hardening process.

U. S P. 1,335,038/20 Ayers. An "artificial stone" adapted for use in sheet form as a roofing material is formed of lime 20, asbestos fiber 2, soapstone 8 and silex 6 parts.

U. S. P. 1,336,178/20 Witty. A cement mixture suitable for artificial marble, brick, etc., is formed of clay 50, finely divided sand or marble dust 20, yellow dextrin 20 and barite 5 parts.

U. S. P. 1,343,929/20 Meyer. A hardening material for lime mortar is formed by burning a mixture of clay with limestone 25–50% and calcium chloride or a similar fluxing agent 5% at a temperature below the clinkering point (preferably about 800°) to drive off carbon dioxide and form a product which reacts slowly with water.

U. S P. 1,351,874/20 Schaller. A light cement adapted for use with cut or ground straw or other vegetable material is formed of casein 20, lime 20–30, caustic soda 2.5–1.25 and borax 5–2.5 parts.

OXYCHLORIDE AND OTHER OXYSALT COMPOSITIONS

B. P. 17,559/08 Fraser. Magnesium chloride, magnesium hydroxide, pulverized spent shale and spent or refuse lime.

B. P. 23,433/08 Fraser. Fireproof composition composed of magnesium chloride, magnesium hydroxide, alum refuse, slag, spent shell, peat moss, and spent lime, preferably from paper mills.

B. P. 23,782/08 Isenschmid. Imitation marble. Magnesium oxide 25%, potassium carbonate 10%, sodium chloride 3%, vitriol 2%, asbestos 60%.

G P. 221,461/08 Ortoclor. Magnesia cement made by dehydrating magnesium oxychloride (equal molecular proportions of magnesium oxide and chloride), adding excess of magnesia, and grinding.

G. P. 229,766/08 Tappert. In the manufacture of moldable artificial stone material from magnesium hydroxide, the latter is precipitated from magnesium chloride solution by means of sodium hydrosulphide, heated and repeatedly washed out, whereupon heated magnesium carbonate and sintered magnesia are worked up into the mass consisting of the hydroxide and the remainder of the sodium magnesium sulphate.

G. P. 235,756/08 Levy. In the manufacture of coating masses containing Sorel cement as binding agent, the magnesite employed is used in incompletely burned state, so that it still contains carbonate.

G. P. 238,329/08 Scherer. Fireproof light porous material, wood fiber or other vegetable fiber is encrusted with magnesia cement and is then moistened with water or magnesium chloride solution and sprinkled with the following powder: burned magnesite 30 to 60; asbestos powder 6 to 12; kieselguhr 3 to 5; anhydrous magnesium chloride 10 to 20.

U. S P. 933,171/09 Gallinowski. Weather-proof artificial stone. Magnesium chloride 3, magnesium oxide 2, powdered silica or mineral wool 2 and barium sulphate 1 part, by volume.

U. S. P. 960,422/10 Siegmann. A composition for building materials, paving blocks, pipe coverings, etc., is formed by combining a mixture of straw 50 lbs., calcined magnesite 70 lbs., asphaltum 5 gals., magnesium chloride (20 deg. Be.) 6 gals., and boric acid 10 oz., with a mixture of stone 100 lbs., calcined magnesite 2 lbs., and magnesium chloride (20 deg. Be.) 0.5 gal.

U. S. P. 968,943/10 Hassack. Making artificial stone plates by mixing together in water about equal parts of fibrous material, as asbestos, and a filler, as magnesite, forming a plate from the mixture, and treating with zinc chloride.

B. P. 12,845/10 Heuschkel. Artificial marble is made from leather waste by freeing the waste from tannic acid, comminuting, adding a solution of magnesium carbonate in hydrochloric or sulphuric acids to which magnesia is added. The pulpy mass is treated with potassium permanganate to prevent the evolution of hydrogen sulphide.

B. P. 29,387/10 Kruse. Plaster compositions made from 3 parts calcined magnesia, 4 parts saturated solution of magnesium chloride and one part of 25% solution of shellac or other gum. Flint, sand, mica, metal, etc., may be added.

G. P. 245,165/10 Eberhard. Preventing the blooming of Sorel cemented articles by adding to the cement mass an alcoholic potash solution of lead chromate.

U. S. P 1,000,386/11 Eggenhoffner. Magnesia cement containing magnesium oxychloride and magnesia, preferably in the molecular proportion of 1 to 7.

B. P. 935/11 Craig. Cement for general building purposes, consisting of a mixture of whinstone in the form of dust, powder, or grit, chalk, calcined magnesite and magnesium chloride solution.

B. P. 5,079/11 Fraser. Manufacturing artificial stone from a mixture of ground slag, coal sludge, calcined magnesite, and magnesium chloride with or without calcined magnesia, sand, oil, or pigment.

B. P. 5,672/11 Scholz A composition for use in the manufacture of floors consisting of magnesite, wood flour, coloring matter, mixed with a solution of magnesium chloride, to which has been added olein, phosphoric acid and blown linseed oil.

B. P. 8,161/11 Herdt. Artificial stone prepared by mixing asbestos and talc in a solution of magnesium chloride, and adding burned magnesite shortly before use, together with fillers and pigments. Oils and fats may also be added.

B. P. 12,977/11 Kruse. Artificial teeth are prepared from a compound such as that described in B. P. 29,387/10 consisting of a mixture of magnesia and magnesium chloride together with sufficient gum or resin to give an enameled surface.

B. P. 19,534/11 Wagner Artificial lithographic stones are made by adding a solution such as a mixture of magnesium chloride and magnesium sulphate to a powder such as a mixture of magnesite and lime, the solid components are mixed in vacuo, adding the solution under similar conditions, the mass being cooled to about one-half deg. C. during the mixing processes. The mass is solidified under hydraulic or oil pressure, a rubber membrane being used to protect the surface of the stone in the former case. The cooling is continued during solidification.

G. P. 258,882/11 Kruse. In the manufacture of an enamel-like mass from magnesia, magnesium chloride and resin, ignited magnesia of about a density of 3 (3 parts) is mixed in the cold state with a saturated aqueous magnesium chloride solution (4 parts), and 1 part of a 25% alcoholic resin solution is worked into the intimate mixture.

B. P. 5,142/12 Calvert. In the manufacture of a composition for treads, polishing wheels, etc., a composition of lead in a divided or granular state and Sorel cement, with or without the addition of any other soft metal such as copper or

abrasive fillers such as stone meal, wood-flour, and carborundum, is used for treads, floorings, lapidaries' stones, polishing wheels and buffs. The proportions are 1 part by volume of lead, 1 of binder, and 1 of carborundum, when used.

B. P. 11,007/12 Fraser. A compound consisting of 30% finely ground magnesite, 5% finely ground calcined magnesia, 3% copal varnish, 21% sand, 1% pigment, 40% magnesium chloride, dissolved in an equal amount of water, is used for the manufacture of artificial stone.

B. P. 27,344/12 Merryless. A non-conducting covering for decks, bulkheads, floors, etc., is composed of calcined magnesite 45 parts, asbestos or sawdust 30, coloring matter 5, with or without powdered granite 15, mixed with 63 parts of a 40% magnesium chloride solution. The surface to be covered is first coated with tar, and sprinkled with powdered magnesite.

F. P. 453,388/12 Boisselier. In the manufacture of artificial stone which resists the influence of the weather, as distinguished from Sorel cement, a mixture of lead carbonate 2%, magnesium carbonate 87%, sodium silicate 1%, powdered feldspar 9%, and caustic soda 1%, and a mixture of hydrochloric acid 80–100 liters of 25° Bé., magnesium chloride 14–16 liters of 22° Bé., zinc sulphate or lead acetate 1–2 liters of 12° Bé., and anhydrous alum 500 grams are mixed, with the addition of sand, emery, pyrites, sawdust, etc., and poured.

G. P. 281,588/12 Kraner. In making artificial stone slabs from the recovered material of the paper and asbestos manufactories, and oxychloride cement, with or without filling, the wet material is mixed with magnesium chloride the water content of which is determined by the amount of water in the material, and then the oxide is added, as in the manufacture of Sorel cement. The wet material consists essentially of kaolin, aluminum sulphate, fiber, glue, and other binders.

U. S. P. 1,067,413/13 Eckschlager. Composition for making artificial stone formed of magnesia 45 lbs., barytes 50 lbs., lithopone 5 lbs., and solution of magnesium chloride 60 lbs.

U. S. P. 1,097,986/13 Moritz. Plastic flooring mixture formed of magnesia 13.3, leather shavings 3.3, fine sawdust 2.5, shredded asbestos 1, powdered talc 1, dry coloring 2, and magnesium chloride solution 19 parts.

B. P. 14,182/13 Porter. Impervious and non-inflammable coverings for the steel plates for ships' decks, etc., of the type consisting of a layer of bitumen, etc., and a layer of cement formed with magnesite, magnesium chloride, etc.

B. P. 19,037/13 Fraser. A plastic magnesite composition is molded and decorated by lining the mold or frame with cloth or paper upon which a design has been printed with a mixture of 50% of liquid magnesium chloride of 56 degrees Tw., 40% of pigment or dye, 5% of calcined magnesia and 5% of extract from hard-wood ash. The compound to be molded consists of 35% of liquid magnesium chloride, 20% of finely ground calcined magnesite, 8% of finely ground calcined magnesia, 30% of sand, 5% of finely ground wood flour or cork, 1% of hard-wood ash extract and 1% of linseed oil.

B. P. 19,787/13 Rossler. A plastic composition, suitable for making slabs or jointless floors, is made as follows: leather waste 100 parts is ground with 20 parts of asbestos, 162 of magnesia, 10 of kieselguhr and 15 of metal oxide, and the product is made into a thick paste with a 25% addition of magnesium sulphate or chloride solution.

F. P. 453,620/13 Wyssling. In the manufacture of a heat insulating agent refractory substances, such as iron slag, coke ash, also sawdust and residues of the glass manufactories and tanneries, are ground together, mixed with equal parts of quartz, asbestos, and magnesia moistened with magnesium chloride, and pressed.

F. P. 454,092/13 Pflatz. Manufacturing building plates by pouring around a vegetable core of rush reeds, a mixture of dye- or tannin-wood waste 150 liters, blast

furnace slag or kieselguhr, or pumice sand 150 liters, magnesite 100 liters, magnesium chloride 200 liters of 24° Bé.

F. P. 455,504/13 Guyot. A compound of matter for covering and filling wood, and the like, comprising magnesia 2.4 kg., saw-dust 0.5 kg., mineral color 0.4 kg., and magnesium chloride 3 liters of 22° Beaumé.

G. P. 273,520/13 Haegele. In a process of manufacturing pressed artificial wood plates from cements and a filling, the sawdust is mixed first with magnesite and the mixture is moistened with magnesium chloride.

U. S. P. 1,078,100/14 Kruse. Artificial stone formed of magnesia 15, magnesium chloride 6 and shellac 1 part.

U. S. P. 1,078,854/14 Fraass. Artificial stone made by mixing asbestos, talc and magnesium chloride solution to form an emulsion and then adding a filler and magnesia.

U. S. P. 1,102,358/14 Siegmann and B. P. 15,038/14 Siegmann. Making a waterproof and fireproof plaster by mixing magnesia 8, magnesium sulphate 4, asbestos 4, rosin 2, kieselguhr 20 and sodium chloride 1 part and adding equal amounts of water and carbon bisulphide to produce the desired consistency for use.

U. S. P. 1,105,950/14 Anderson. Making imitation marble by pouring into a mold a facing mixture which has been made by adding a solution of magnesium chloride and zinc chloride and a filler such as silica, marble dust or sawdust, to a dry mixture of magnesia and lead acetate; then adding a backing mixture which has been formed of a similar mixture, containing coarse silica as an additional ingredient, and allowing the materials to set together.

U. S. P. 1,094,366/14 Heuschkel. Making imitation marble by soaking scraps of leather in hot caustic alkali solution, removing the solution and treating the material with an acid at about 75 deg. to convert the tannic acid into gallic acid and carbohydrate, soaking the mass in permanganate solution to prevent cohesion of the separate particles, drying at 85 deg. to convert the gallic acid into pyrogallol, mixing with a solution formed by dissolving magnesite in hydrochloric acid and combining with magnesia and finally shaping and drying this plastic material.

U. S. P. 1,117,443/14 Reuter. Making a dry magnesium chloride mixture for use in forming Sorel cement by adding magnesium sulphate 5 to a mixture of dehydrated magnesium chloride 100 and magnesium carbonate 20 parts, heating sufficiently to form an anhydrous mixture after the conversion of all the calcium oxide or hydrate present as impurity into sulphate. This mixture may then be mixed with magnesia, 250 parts, and is kept in sealed containers.

U. S. P. 1,119,550/14 Taylor. A composition for flooring, building slabs, etc., is formed of wood flour 20, magnesia 71 parts, sufficient 21 degrees Beaumé magnesium chloride solution to make a plastic mixture and small amounts of phosphorous acid, olein, blown linseed oil and coloring material.

B. P. 24,667/14 Garnett. A decorative slab having a highly polished surface is produced with a composition made up of 40% ground calcined magnesite, 10% ground pumice stone, 5% gypsum, 3% sand, 2% coloring matter and 40% magnesium chloride, which is pressed on to a stone base by means of a polished plate of metal, glass etc. The base is prepared by coating with shellac or gum varnish and dusting with sand.

G. P. 292,104/14 Rudiger. A cement-like building material, waterproof and lighter than water is made of kieselguhr and trass with magnesia and magnesium sulphate as binders. The addition of the sulphate is used to prevent corrosion of the iron reinforcing, which would be accelerated by magnesium chloride. Ground pumice stone, coke, slag, or blast-furnace slag sand may be added also.

G. P. 293,283/14 Wallin. In making structural members from magnesia cement magnesium nitrate is used instead of the chloride or sulphate. The materials may be mixed dry at the factory and water added when used.

U. S. P. 1,123,600/15 Sanderson. A plastic mixture for making molded dress forms, etc., is formed of asbestos 70, dental plaster 20, China clay 5 and glue 5 parts.

U. S. P. 1,130,240/15 Ayers. Shingles are made from a mixture of magnesia 16, asbestos fiber 2, soapstone 6, silex 3, wood pulp 3, and aluminum chloride (36 deg. Bé. solution) 6–8 oz.

U. S. P. 1,136,370/15 Scharwath. Paper, wood or cloth is rendered fireproof and waterproof by dipping in a bath formed of magnesia 10, sodium silicate 150, fire-clay 125, "red manganese oxide" 10, "manganese oxide" 50, and water 300 parts, baking at about 200 degrees C. and then dipping in a bath formed of magnesia, magnesium chloride and water.

U. S. P. 1,153,032/15 Conn. Artificial stone is made by mixing concentrated sulphuric acid 1 with litharge 3 parts, adding a solution of magnesium chloride 175 in water 226 parts and stirring until the reaction ceases, and then adding a mixture of lime sulphate 210, magnesite 105, and sand 280 parts, and molding.

B. P. 13,075/15 Ogawa. An artificial stone material is composed of incompletely burned dolomite mixed with magnesium chloride solution and cork or sawdust, with a surface layer of similar material, in which the filler is asbestos or slag-wool. Finely powdered dolomite is heated to 700–800 degrees, when the magnesium is reduced to oxide but the calcium carbonate is left unchanged.

U. S. P. 1,183,446/16 Freeman. For making floors, sinks, switch-boards, etc., partially hydrolyzed cellulose, prepared from sawdust, straw or other refuse cellulosic material, is dried and mixed with dry magnesia and later prepared for use by addition of a magnesium chloride solution.

U. S. P. 1,190,942/16 Nienstaedt. For a floor-covering composition, asbestos, clay, granular cork, linseed oil, split textile fiber and magnesite cement are mixed together to form a smooth troweling composition. Silex, calcium sulphate and sugar may also be added to vary the hardness and setting properties.

U. S. P. 1,192,460/16 Roessler. A mixture for making floor coverings is formed of leather waste 100, asbestos 20, magnesia 162, kieselguhr 10, coloring material 15 parts and sufficient magnesium sulphate solution to serve as a binder. Casein, glycerol, linseed oil and slaked lime may also be used in similar mixtures.

B. P. 107,402/16 Ardagh. A mixture of ground cocoanut shell or fiber, or both, with calcined magnesite and magnesium chloride solution is used for making fire-resisting boards or blocks for use in walls, roofing, flooring, etc. The composition may be applied also to woodwork, cardboard, felt, canvas, etc.

B. P. 103,775/16 Sperni. A composition for roofing, wall coverings, floors, etc., is made of 50 parts sawdust and 25 parts each of burned magnesite and pumice, treated with sufficient magnesium chloride solution of 18–25 degrees Beaumé to produce a semi-dry mass. In laying a floor, raw linseed oil may be added, e.g., 1 gal. to 25 gals. of magnesium solution, and if a wooden foundation is used, this is treated with a grout consisting of 75 parts burned magnesite and 25 parts magnesium chloride solution with the addition of sodium silicate solution of 18 degrees Beaumé, in amount 25% of the chloride.

U. S. P. 1,212,575/17 Siegmann. A mixture for floors, insulation and other uses is formed of magnesia 40, colophonium 2, magnesium sulphate 10, salt 5, kieselguhr 10, barium carbonate 3, straw, cork or other fibrous material 30 parts and sufficient water or carbon bisulphide to produce a plastic mixture. Calcium sulphate, boric acid, borax and asbestos may also be added.

U. S. P. 1,241,531/17 McCulloch. About 5% of calcium saccharate is added to magnesium oxychloride cement to prevent expansion on setting and to increase the viscosity of the wet mixture so it does not readily penetrate fibrous materials.

U. S. P. 1,245,329/17 Gernert. A flooring composition is formed by the addition of magnesium chloride solution to a mixture of magnesia 75, asbestos fiber 10, silex 12, finely divided cork 25 and coloring material 8 parts.

U. S. P. 1,253,011/18 Davey. A cement suitable for stucco-surfacing on walls of building is formed of calcined magnesite 500, sand 1068, long and short-fibered asbestos (the latter in sufficient amount to make the cement work easy) 132, magnesium chloride solution and cork particles of about 20 mesh 300 parts.

U. S. P. 1,256,847/18 Turner. A stucco is formed from a mixture comprising magnesium chloride 1, magnesia 1, powdered cork 1, asbestos fiber 2, sand 5, lithopone 0.1, and an insoluble soap, which serves as a waterproofing agent, 0.1 part.

Swiss P. 78,065/18 Frey. A mixture of sawdust and magnesia is agglomerated by means of a solution of magnesium chloride of 32 deg. Bé., magnesium sulphate of 30 deg. Bé., and aluminum sulphate of 28 deg. Bé.

U. S. P. 1,300,501/19 Sorel. A lining for bearings is formed of a lubricating conglomerate of ground graphite and powdered magnesia mixed with a solution of magnesium chloride and a solid fatty substance such as stearin. Vulcanized rubber, gum lac or hardened plaster may be included in similar mixtures.

U. S. P. 1,318,075/19 Grunwald. A material for monolithic structures is formed by association of a wet mixture of magnesia and magnesium chloride with a mixture formed of dead burned magnesite and crude finely divided magnesite. The latter mixture is obtained as so-called "magnesium sand" as a residue in the manufacture of magnesium carbonate from magnesite.

U. S. P. 1,333,510/20 Shaw. Magnesium limestone is calcined under such conditions as to decompose the magnesium carbonate which it contains without material decomposition of the calcium carbonate, (e.g. by heating at 500–815 deg.) and a cement is formed by mixing this product with a solution of magnesium chloride or calcium chloride or both.

CHAPTER III

GLASS: ITS HISTORY AND MANUFACTURE

There is an old copybook maxim which says "Familiarity breeds contempt." It would probably be more correct to say that familiarity breeds indifference. We take little heed of objects around us which have formed part of our environment as far back as our individual memory extends. We just take them for granted. Every house you ever lived in, had glass windows. Of course—for who would think of building a house without them!

But, after all, it is not quite such a matter of course. Glass windows were not by any means always as common as they are to-day. Even in such comparatively recent times as the days of Queen Elizabeth glass windows were a luxury afforded to the wealthy, and we read of a certain nobleman of that time who, upon leaving his residence on a prolonged absence, had all his windows carefully taken out and stowed away in a safe place. It is true that the Romans in the early days of our present era were most skilled in the art of making fine glassware; colored and ornamental glass were used by them for tableware in much the same way as porcelain is used by us to-day, and undoubtedly they also had glass windows; but possibly not as a common feature. During the middle ages the art of manufacturing glass degenerated, as did so many other accomplishments of classic civilization. How did men get along without glass to let the daylight into their dwelling places and public buildings? And how did they carry a light at night in the open, since they had no glass from which to make lantern windows?

The earliest windows were probably similar to those found in the Great Hall of Columns of the ancient Egyptian city of Thebes, "the ruins of Karnak," as they are named to-day. These windows were filled with vertical slabs of masonry pierced with narrow slits. The Pantheon built in A. D. 120 by the Roman Emperor Hadrian was lighted by a thirty-foot opening in the dome, which let in the rain as well as the light. Among the Greeks and Romans thin translucent slabs of marble, and also mica, were also used for windows. Lanterns, even in comparatively recent times, were commonly fitted with horn sides. But after all, these are mere makeshifts as compared with our modern method of lighting buildings by means of glass windows by day, and with electric light bulbs at night. The Woolworth building in New York alone has some five thousand outside windows and over 14000 electric light bulbs.

It requires a distinct effort of the imagination to realize just what the widespread use of glass in modern civilization has meant to industry.

Imagine the handicap of the modern manufacturer were he to attempt to carry on operations without the aid of glass windows. Work would either have to be done in the open air, with such interruptions as rain, wind, and frost might dictate, or else under a very imperfect light. In brief, modern industry, on its present scale, would be an impossibility.

While the use of glass for windows is no doubt the largest single item in the consumption of that material, there are many other uses in which this substance makes itself indispensable to us. A large proportion of our adult population, and the majority of persons above forty or fifty years of age, wear eye glasses. All of these would be handicapped, some of them would be rendered almost helpless without them. There was a time when such persons had to manage as best they could in spite of their handicap, but due to modern progress optical conditions can be either corrected or aided. Then again, consider the newest of all industries, the moving picture production. Nightly millions of people find relaxation in the film play. The matter in itself may not appear very important. Certainly we were able to live without this luxury twenty-five years ago. But the very voluminous expansion of the industry on the one hand is evidence of the fact that it fills something of a real popular need, and, on the other hand, gives it an importance quite independently of the estimate which we may be disposed to place upon the intrinsic value of the film drama. Yet Edison with all his ingenuity could never have instigated this industry without the services of the camera's glass eye.

The incandescent electric lamp and its more modern descendants, owe their very existence to certain properties in which glass stands unique: transparency, coupled with considerable strength to withstand atmospheric pressure upon the exhausted bulb, and almost perfect impermeability to gases. And from the incandescent lamp bulb it is only a step to that other scientific instrument, the X-ray tube, which has not only given into our hands a most valuable tool for surgical diagnosis, but which has been very largely instrumental in unlocking for us the mysteries of the ultimate constitution of matter. For it is by the study of the electric discharge through rarefied gases, in so-called vacuum tubes, that Thomson was led to the discovery of the electron, the ultimate constituent, as it seems to-day, of all matter.

Then again, consider modern bacteriology, and the innumerable lives that have been saved through the light thrown by it upon the cause of diseases, and upon the best methods of fighting them. This is one of the debts we owe to glass, for without this substance the construction of a microscope would be at best an extremely difficult and costly matter. And as the microscope has opened our eyes to the world of diminutive dimensions, so, at the other end of the scale, the telescope, with its glass lenses and mirrors, has pierced for us the unsounded depths of the cosmos.

Far from exhaustive is this brief survey of some of the principal uses in which glass has made itself indispensable to modern civilization and invaluable in the progress of science; but it will serve to call attention to the extraordinarily important rôle played, with unob-

trusive modesty, by this remarkable material, for it is remarkable, but familiarity tends to make us blind to the fact.

And glass is to be reckoned among the plastic materials. For though in actual use it appears hard and brittle, in the process of its formation into articles for use, it is softened by heat and shaped by the application of pressure. Incidentally, one method of applying such pressure is peculiar to the glass industry: the use of a blast of air, either from the workman's lungs or from an industrial source of compressed air.

The manufacture of glass comprises two separate and distinct processes, namely:

1. The production of the glass substance from certain raw materials. This is essentially a chemical operation.
2. The manipulation and mechanical treatment of this product to fashion various articles of use therefrom.

We will consider each of these in turn.

GLASS PRODUCTION

Glass is not one single substance of invariable composition. The term glass, on the contrary, is employed to denote a class of substances which have certain characteristics in common, though they may vary within wide limits in such properties as color, transparency, resistance to heat, etc. To attempt a rigorous definition of glass is to invite defeat. We may content ourselves with enumerating and describing the preparation and properties of some of the principal representatives of this class of substances. Further definition is needless.

The most typical glasses, and in fact all but a few optical glasses ranking rather as curiosities than as practical members of the family, are silicates, that is to say, combinations of silica with metallic bases. The non-chemical reader may substitute the word "sand" for silica, for most sands are more or less pure silica, and sand is, indeed, one of the raw materials employed in the manufacture of glass.

The bases present in the varieties of glass in common use are the alkalies, soda, Na_2O, and potash K_2O; the alkaline earths and some other divalent bases, lime CaO, magnesia MgO, zinc oxide ZnO, manganese oxide MnO, and lead oxide PbO. In addition to these, glasses may contain the oxides of aluminum and iron, Al_2O_3, and Fe_2O_3, the latter as an impurity, especially in common, dark colored bottle glasses.

The character of the glass depends on the presence or absence, and the relative proportions of each of these constituents. So, for example, silicates of the alkalies alone are soluble in water, and are commonly known as water-glass. This solubility renders them useful for certain special purposes, for example as agglutinants or binders in the preparation of certain cements or plastic compositions. It renders them, of course, wholly unfit for most of the uses to which typical glasses are ordinarily put. These alkali silicates are made by fusing sand with potash or soda. The product is a readily fusible transparent mass which is more or less completely soluble in water according to the pro-

portion of silica in the mix. The higher the content of silica, the less easily fusible is the product, while at the same time the indissoluble residue increases.

The silicates of calcium, barium, alumina and magnesia, when unmixed with other silicates, are very difficult to fuse, especially the last two. Calcium and barium silicates are slowly attacked by water.

The silicates of lead are more readily fusible, and, in point of fact, are a typical constituent of some of the more fusible commercial glasses.

Glass, the regular commercial product, always contains silicates of several of the bases enumerated in the preceding paragraphs. It does not, in general, correspond to any definite chemical compound, but seems to represent mixtures or solutions of the several silicates in one another and in such excess of silica as may be present. The melting point of such combinations is always lower than the mean melting point of the constituents, and often lower than the melting point of any of the constituents.

The silica of glass may be replaced in part by other acidic radicals, in particular by boric and phosphoric acids. Borate and phosphate glasses have also been made containing no silica at all, but these represent curiosities rather than staple products.

STAPLE VARIETIES OF GLASS

Crown Glass: This term is commonly employed to designate a type of glass employed for windows, chemical glassware, bottles of higher grade, etc. Crown glass is essentially a soda-lime glass, though it may also contain BaO and a small proportion of alumina.

Flint Glass: This derives its name from the fact that formerly ground flint was used in the place of sand in the manufacture of glass of this quality. This practice has now been abandoned. Flint glass is essentially a potash-lead glass. It is used in the manufacture of finer glassware for the table (the French "cristal"), for hollow ware, and for optical glass. Its high refractive index gives it a certain brilliancy and is valuable for certain optical applications.

Bottle Glass: The commoner types of green, yellow and brown bottles, as used to contain beverages, are usually made from a glass containing soda, lime and alumina. Such glass presents the advantage of combined strength and insolubility, while economy can here be secured through the less stringent demands placed upon the purity in the raw materials, since color is a matter of indifference.

Bohemian Glass: The glass known under this name and commonly used for hollow ware is a potash-lime glass.

Special Glasses: Glasses of special composition, or prepared by special treatment, are of great importance in the manufacture of optical and other instruments for scientific and technical use, such as thermometers, pressure gages, microscopes, telescopes, transits, etc. The fact that the industry of these glasses was very largely centered in Germany placed upon our manufacturers and technicians a variety of

highly urgent and difficult problems during the war, problems in the solution of which they achieved most gratifying successes.

Silica Ware: Silica itself, uncombined with any base, is capable of being fused at the very high temperature of the oxy-hydrogen or the electric furnace and shaped into vessels or other utensils for scientific and technical use. The industry of the manufacture of such ware has of late years developed to considerable perfection and extent. Two kinds of ware are upon the market, the one transparent, resembling ordinary glass in appearance, made by fusing quartz in a furnace heated with oxy-hydrogen flame. The forming and manipulating of such articles in the process of manufacture is naturally a more difficult matter than ordinary glass blowing, and the scope of this kind of ware is correspondingly limited in point of shape and complication of structure, as compared with glass utensils. Nevertheless distilling flasks and sundry more or less intricate pieces of apparatus are among the regular catalog items of the firms putting out this product. The highly refractory character of the ware, while forming a somewhat unfortunate obstacle to its ready and cheap production, is, of course, an advantage in its use for certain purposes. This vitreous variety of silica ware also possesses another advantage in its remarkably low coefficient of expansion with temperature, as the result of which very little strain is produced in the material by sudden changes of temperature. It is claimed that the material can be heated to redness and then plunged into cold water without cracking.

In its optical properties this transparent silica ware is distinguished from ordinary glass in being transparent to the ultra-violet rays of the spectrum. It has for this reason been used in the construction of mercury vapor electric lamps, the light from which is rich in such rays, although special glasses have also been made which share, in some degree, with quartz, this property of transmitting rays of short wave length.

The other variety of silica glass is made by fusing sand in the electric furnace, the sand itself forming a temporary furnace bed, for no substance could withstand the temperature of the electric arc. The material so produced is opaque owing to the inclusion of air spaces between the grains. Apparatus of quite large dimension for operations on a factory scale are made from this material: basins, pipes, distilling columns, retorts and so forth.

RAW MATERIALS

Silica: While other sources of silica are available, such as flint, and quartz, modern glass manufacture makes use principally of sand and sandstone for this purpose. For the higher grades of glass a pure sand free from iron is essential, since impurities would color the product more or less deeply. In several localities sands of remarkable purity are found, analyzing as high as 99.98% silica. In the United States glass sands or sandstones are produced principally in Pennsylvania, Illinois, West Virginia, Missouri, Ohio and New Jersey. The

composition of some typical glass sands from various sources is shown in the following table given by H. Ries in his Economic Geology:

CHEMICAL ANALYSIS OF GLASS SANDS

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO
1. Ottawa, La Salle Co., Ill.	99.45	.30	—	.13	tr.
2. Utica, Ill.	99.57	.283	.0903	.0197	.002
3. Klondike, Mo.	99.97	.03	—	—	—
4. Grays Summit, Mo.	99.84	—	.0014	—	—
5. Everton, Boone Co., Ark.	99.55	.13	.09	—	—
6. Flora, Grant Co., Wis.	99.17	.25	.22	—	—
7. Coxville, Ind.	98.61	.74	.22	.12	tr.
8. Tip-Top, Ky. (selected)	98.87	.21	.08	.24	.12
9. Massillon, Ohio	97.50	1.50	.50	—	.50
10. Niles, Ohio	99.915	.062	.0019	.021	tr.
11. Berkeley, W. Va. (Oriskany Sandstone)	98.99	.7717	.0383	—	—
12. Hancock, W. Va. (Medina Sandstone)	99.30	.5186	.0314	—	—
13. Columbia, Pa. (Oriskany)	99.50	.1337	.2898	—	—
14. Cheshire, Mass. (Cambrian)	99.46	.48	.06	—	—
15. Lewiston, Pa. (Oriskany)	98.84	.17	.34	tr.	tr.
16. Hanover, N. J. (Tertiary)	97.70	.755	.15	.955	.442
17. Clayton, Ia. (Ordovician)	98.85	.46	.995	.21	—
18. W. Vienna, N. Y. (Pleistocene)	98.6	.17	.23	—	tr.

The presence of iron in glass sand is objectionable except for coarse bottle glass, on account of the color which it imparts to the glass. For window glass one-half of one per cent of iron is the limit permissible. For coarse bottle glass as much as two per cent may be admitted, so that common sand can be used.

Alkalies: It is a somewhat remarkable fact that the glass of the Romans approached more nearly to most of our modern glass than did the products of the middle ages. This is due to the fact that the alkali base of Roman glass was soda, introduced into the mix in the form of the mineral *natron* (a native sodium carbonate), while most of the medieval glass was made with wood ashes, that is to say, crude potassium carbonate. Modern glass is predominatingly a soda glass, though potash is also used to some extent. The soda is introduced either as the carbonate (common washing soda, or soda ash), or else as the sulphate, so-called salt cake, obtained by the decomposition of common salt with sulphuric acid, as a by-product in the manufacture of hydrochloric acid. When using the alkali in the form of sulphate it is usual to add also a certain amount of anthracite or charcoal as a reducing agent for the sulphate. For the manufacture of most kinds of glass, except lead glass, salt cake presents certain advantages over the carbonate. It is cheaper per unit of alkali, and its use permits the employment of a higher temperature in the glass melting furnace; in consequence a higher percentage of silica can be put into the glass, thus again reducing the cost of raw materials while at the same

time producing a harder and more durable glass. Against this must, of course, be set the increased cost of fuel in working at the higher temperature.

Potash, when used in glass making, is introduced in the form of carbonate, so-called pearl ash, which in modern times is manufactured from potash salts such as occur in the deposits of Stassfurt.

A portion of the alkali may also be used in the form of nitrate, in which case its principal function is to act as an oxidizing agent, particularly in lead glasses.

Lime is introduced in the form of limestone, chalk or slaked lime. The use of slaked lime presents the advantage that it avoids the evolution of carbon dioxide gas during the process of glass melting. It is true that instead of this, water vapor is given off, but this evolution occurs at a lower temperature, at a less advanced stage of the operation, so that there is better opportunity for the complete expulsion of the bubbles formed.

Barium occurs in nature as the carbonate, Witherite, and as the sulphate, Barytes or Heavy Spar. Both these minerals are employed in making barium glasses, as are also artificially prepared salts of this metal.

Magnesia is ordinarily shunned rather than sought as a constituent of glass. When introduced intentionally in the production of certain special glasses, it enters either as carbonate or oxide, the former being found in nature as magnesite, the latter prepared therefrom by calcination.

Zinc Oxide, occasionally an ingredient of the glass mix, is prepared commercially by burning metallic zinc.

Aluminum is introduced into hard glasses in the form of hydrate; certain milk-white glasses (opal glass) owe their coloration to the presence of alumina which has been added in the form of cryolite, a mineral consisting of the double fluoride of sodium and aluminum. Artificial cryolites, which are cheaper than the rather scarce mineral, have been successfully substituted in its place.

All glasses contain at least a small proportion of alumina as an impurity taken up from the refractory pots or tanks made from clay, in which the glass is melted.

Manganese is commonly added, in the form of the dioxide MnO_2, to correct for the greenish coloration produced by iron. In larger quantities manganese imparts an amethyst to violet color to glass, and is so used when such color is desired.

Lead is used in the form of red lead, an oxide or mixture of oxides having approximately the composition corresponding to the formula Pb_3O_4, produced by oxidizing molten metallic lead in a current of hot air.

Lead glasses are heavy, comparatively easy to fuse, and brilliant in appearance owing to their high refractive index. Paste diamonds (so-called strass) are made of potash-lead glass, the potash being especially purified by converting it into caustic potash and treatment with alcohol. The fact that lead glass is among the softer varieties

of glass is rather unfortunate for the wearing qualities of such artificial gems.

Carbon, when forming an ingredient of the glass mix, in particular when the alkali is sodium sulphate, is added either as anthracite or as charcoal.

Arsenic in the form of trioxide, As_2O_3, is frequently added to the glass mix as a decolorizing and oxidizing agent, and to prevent reduction of the lead oxide, in the case of lead glass, which would be blackened by such reduction.

Cullet. This is the name used in the trade to designate fragments of broken glass which always form part of the mix. Their function is duo-fold. On the one hand they furnish a ready opportunity to utilize waste pieces of broken glass, both those resulting in the actual manufacturing operations, and also those gathered from other sources. On the other hand they facilitate the fusion of the mix, especially in its initial stages.

The several ingredients, reduced, where necessary, to a suitable state of fine division, are mixed either by hand or, preferably, by machinery. Mechanical mixers may take the form of revolving drums or of receptacles provided with a central rotating shaft to which stirrer arms are attached. The mixing is continued until the material appears sensibly homogeneous. The cullet is added separately after all the other ingredients have been thoroughly mixed.

GLASS MELTING FURNACES

Two distinct types of furnaces are used for glass melting, pot furnaces and tank furnaces. When using pot furnaces the glass is melted in individual batches contained in pots or crucibles placed in the chamber of the furnace. Such crucibles vary in capacity from four hundred weight to two tons and more, of glass; the most usual size, however, measure from 30 to 50 inches in diameter.

While in the pot furnace a number of relatively small individual batches are melted in separate crucibles, the tank furnace operates with a large body of glass filling the entire tank or basin into which the floor of the furnace is formed.

As regards the relative merits of the pot furnace and the tank furnace, it must be said, in the first place, that for the commoner grades of glass the tank furnace has undoubtedly the advantage of economy. Not only does it eliminate the cost of the pots, but it utilizes much more completely the space (and therefore also the heat) of the furnace, since the entire floor is covered with the glass melt. At the same time it offers the obvious advantages of continuous working. The constant level of the glass in the tank is also a great convenience in drawing the product from the furnace. Preference will therefore be given to the tank furnace whenever the quality of the product desired warrants its use.

For high grade and special glasses, on the other hand, the pot furnace will often be given preference, or will be indispensable, as the

composition of the glass is under more direct control and the melt can be more perfectly protected from contamination with foreign matter from the furnace walls or from the fuel gases.

MANIPULATION AND MECHANICAL TREATMENT OF GLASS IN THE MANUFACTURE OF GLASSWARE

In the majority of cases the manufacture of various articles of glass is conducted in immediate conjunction with the production of the glass itself from the raw materials. The glass is drawn directly from the melting furnace to be immediately worked up, while still soft, into bottles, sheets, plates, molded or pressed articles, etc.

The peculiar properties of the semi-liquid hot glass offers every opportunity for the exercise of the skill of the workman and the ingenuity of the designer of modern machinery and processes.

Blown Glass: Much of the work is still done by the older methods of glass blowing and manual operation. It is only by actually watching a glass blower at work that one can properly appreciate the remarkable dexterity of the worker as well as the strangely adaptable nature of the material on which he practices his art. The first step is to "gather" the requisite quantity of molten glass from the pot or the tank in the furnace. This is done by dipping the end of an iron tube about four or five feet long into the molten glass, which has about the consistency of syrup at this stage. A single dipping does not take up the necessary amount of glass on the end of the tube, so the quantity first gathered is allowed to stiffen a little, and is then dipped again to gather a further quantity. This step is repeated until a lump of glass large enough for the article to be fashioned is collected at the end of the pipe. Then begins a series of manipulations: A bulb is blown, very much like an overgrown, heavy soap bubble, elongated by the force of its own weight and by centrifugal action as the operator swings the bulb around in a semi-circle at the end of the long pipe; by a dexterous touch here and there, with various hand tools, the bulb is gradually fashioned into the rudiments of a bottle, a flask, a cylinder, or any one of the numberless forms of handblown glass in which this highly plastic material appears on the market. The finishing touches will vary greatly according to the nature of the article being made. In the manufacture of sheet glass (window glass) for example, the first result of the blower's operations is a glass cylinder closed at each end by an approximately hemispherical dome. These ends are cut off, and the resulting cylinder is allowed to cool. A cut is then made with a diamond along the inside of this cylinder, and the split cylinder is laid down flat on a smooth stone in a furnace in which it is heated to the softening point. Thus the cylinder unrolls, the flattening out being assisted by applying over its surface a block of wetted wood, or by more modern mechanical appliances.

In making bottles the first steps are somewhat similar to those just described, allowance being made for the difference in the shape aimed at. In modern practice, however, the exact shape of the article

is not left to the skill of the workman to determine, but is mechanically fixed by blowing the bulb into a hollow mold, against the walls of which the glass becomes applied by the pressure of the blast. The neck is finished in a separate operation, either by applying a collar of glass around it after the neck has been severed from the blow pipe, or by softening the neck by reheating it, and molding it to shape with a special tool.

In the modern industry many mechanical aids for the glassblower ease his work, which at best is far from a light task, nor an agreeable one, since in gathering his glass he is forced to work within a few feet of the hot furnace. Some of these mechanical aids serve merely to relieve him of the weight of the glass at the end of the blow pipe, which, when blowing large objects, is no small item. In such cases, the use of compressed air instead of the workman's breath is a necessity rather than a convenience. Formerly, in making large carboys, and the like, the glassblower injected water into the vessel during the operation, thus making use of the expansive power of the steam to force out the sides of the vessel. The use of compressed air not only simplifies such operations as this, but renders possible still larger work, such as the making of large glass tanks, bath tubs and the like. These can now be made by an almost wholly mechanical process. A slab of glass is poured and rolled out over a perforated iron plate, and its edges are clamped down by a frame of suitable size and shape which fits all around the portion of the glass that will form the margin or flange of the tank, while the central portion is left free. The perforated plate is then turned bottomside up, leaving the sheet of glass suspended from the marginal frame. Compressed air is then blown through the perforations in the plate, so that the sheet of glass hanging from the frame bulges out to form the body of the tank. The proper shape is secured by receiving the glass in a mold placed under the plate, against the sides of which the glass is pressed by the blast.

Plate Glass: There is an obvious limit to the size of glass sheets which can with any degree of convenience be made by blowing a cylinder and flattening it out, as described above. Moreover, the glass so made is not free from blemishes, particularly as regards the planeness of its surface. Everyone is familiar with the flaws of ordinary window panes, which cause objects seen through them to appear more or less distorted. These flaws are due in part to air bubbles, in part also to the impossibility of smoothing out the sheets perfectly flat. For ordinary windows, whose chief function is to let in daylight, such minor blemishes are of no consequence. But where large plates of high quality are essential, as in shop windows, display cases, etc., another method of manufacture becomes imperative. In this case the glass is cast or poured out in large slabs on to a flat table of iron or of phosphor bronze, preferably built up in segments to overcome the effects of unequal expansion. The sheet is rolled out to an even thickness by means of a roller, and after cooling its surfaces are made accurately plane by grinding and polishing. About one-third of the weight of the plate is lost in this grinding and polishing operation.

PATENT REFERENCES

GLASS

B. P. 1,790/10 Benedictus. In the strengthening of glass sheets by means of celluloid, treating the celluloid with one of its solvents until the surface to be attached to the glass softens, and then subjecting the superporous glass and celluloid to considerable pressure.

B. P. 10,324/11 Benedictus. Manufacturing compound transparent sheets, comprising two glass sheets and a sheet of gelatin between.

B. P. 10,293/11 Benedictus. Manufacturing compound sheets comprising two glass sheets with a sheet of gelatin between.

G. P. 267,563/11 Benedictus. Production of joined glass with a compound consisting wholly or partly of gelatin. The dry gelatin is moistened by a neutral liquid, such as 90–95% ethyl alcohol or methyl alcohol, which gives up only sufficient water to soften the gelatin in the heat and render it adhesive.

B. P. 18,300/12 Gen. Elec. Co. Tough glass made by adding silica to a borosilicate glass.

G. P. 292,737/12 Kuppers. To secure an exact bore in glass and like tubing it is reheated and compressed upon a core of the desired diameter.

B. P. 15,386/13 Triplex Glass Co. An improvement on the methods of making the compound glass sheets described in 1,790/10, 10,293/11, 10,324/11 and 17,549/12, in which a sheet of celluloid. etc., is secured between sheets of glass by means of suitable solvents and adhesives.

B. P. 15,387/13 Lyttleton. An improved method for sealing the edges of compound glass sheets which are comprised of two layers of glass with a sheet of transparent pliable material between.

B. P. 15,880/13 Paschke. Compound glass sheets are formed by coating, one side of each of two glass sheets with a solution of cellulose acetate in a suitable solvent, such as tetrachlorbenzene or chloroform, the coated glass sheets then being pressed together before the cellulose acetate films are quite dry or after they have dried.

F. P. 17,159/13 Wolf-Burckhardt. Addition to 432,786. In the manufacture of a glass resistant to chemicals and heat, natural silica, pure and anhydrous, is fused with the high-fusing oxides, possessing acid character, of aluminum and the rare earths or those of chromium and related earths.

G. P. 287,394/13 Becker. Production of crystalline glass masses from glass tube stock. The molten charge is removed before its several parts have flown into a clear mass, and worked in that condition. If a glass stock without alumina, and consisting of sand 100, soda 40, and lime 30, is fused, a product is obtained which is granite-like in its character, without having been ignited.

G. P. 293,964/13 Podszus. Molybdenum or molybdenum-tungsten wire may be sealed tightly into quartz vessels with the use of a mixture consisting of 10 parts silica, 1 part alumina and 1 part boron oxide.

U. S. P. 1,098,342/14 Benedictus. Reinforcing sheet glass by softening a sheet of celluloid by treatment with a volatile solvent and then pressing glass sheets upon both sides of the softened celluloid so as to cause them to firmly adhere.

U. S. P. 1,113,208/14 Ehret. In making wire glass an electric current is passed through both the wire and the glass to heat them while the wire is being embedded in the glass.

U. S. P. 1,141,932/15 Burnes. Making wire glass by simultaneously drawing two sheets of glass with a layer of wire fabric between them and pressing the sheets together as drawn.

B. P. 9,178/15 Wiese. In the production of compound sheets comprising

two glass sheets with a sheet of gelatin secured between them, the sheets of glass are coated with a solution which is fluid when cold. When the coating has set, two sheets are placed with their coated surfaces together, and heated under pressure. The gelatin solution is produced by the action of hydrogen peroxide, acetic acid and zinc chloride on the gelatin.

U. S. P. 1,182,739/16 Benedictus. Two sheets of glass are united by heat and pressure with an intervening layer of gelatin moistened with 90-95% alcohol.

U. S. P. 1,191,630/16 Weintraub. A tough strong glass with a coefficient of thermal expansion less than .0000035 and adapted for sealing tungsten or molybdenum wires into quartz tubes is formed of silica 72 or more, boron oxide 11, magnesia 3–4 and sodium oxide 12 parts.

U. S. P. 1,192,474/16 Taylor. Glass having a coefficient of expansion of less than .0000056 and suited for the manufacture of culinary vessels is formed of silica 71, boron oxide 28, and lithium oxide 1%; or silica 75, boron oxide 15, lithium oxide 1, alumina 5 and sodium oxide 4%; or silica 70, boron oxide 13, lithium oxide 9, alumina 2 and antimony trioxide 5%.

U. S. P. 1,203,409/16 Rickmann. Enamels such as may be formed of feldspar, silica, borax and soda are rendered more acid-resisting and given whiteness and opacity by the addition of a small proportion of potassium metantimonate.

U. S. P. 1,206,177/16 Twyman and B. P. 103,233/16 Twyman. Surfaces of glass melting at about 1100 deg. and annealing at 600 deg. are joined by placing them in optical contact and pressing them together at a temperature of 520 deg. or slightly lower. Used for making prisms, lenses, etc.

B. P. 111,539/16 Goldreich. In making strengthened glass comprising two sheets of glass and an interposed sheet of celluloid, the celluloid is treated, not with a solvent, but with a softener, such as industrial spirit, and is caused to adhere to the glass by the action of heat and pressure.

U. S. P. 1,210,987/17 Roosevelt. A transparent coating on glass, which will prevent scattering of fragments of the glass when broken, is formed by successive application to the glass of a solution of gelatin in formic acid and a solution of celluloid in acetone.

U. S. P. 1,214,202/17 Macbeth. Glass for blown illuminating ware is formed from a foundation batch containing zinc oxide and capable of making a clear glass 1500, alumina 80–160, fluorspar 100–170 and sodium silico-fluoride 100–200 parts. The foundation batch may consist of sand 1000, potash 190, zinc oxide 240, borax 66 and salt 5 parts.

U. S. P. 1,223,135/17 Bardin. Two plates of glass are united and reinforced by applying to one of them superposed layers of gelatin, celluloid, gelatin and varnish; applying varnish to the other plate.

U. S. P. 1,228,165/17 Bardin. A transparent reinforced glass is formed by successively coating with gelatin, a dilute solution of nitrocellulose in ethyl formate which produces a haze on solidifying, a 2–3% solution of celluloid in acetone 30, ether 30, amyl acetate and amyl alcohol 10, to remove the haze so formed, a 5–15% solution of celluloid in a similar mixture of solvents and a final protective coating of varnish.

U. S. P. 1,261,015/18 Enequist. Fused lapidolite is added to an unfused batch of glass-making materials which is then fused. The lapidolite may constitute 1–50% of the entire mixture and enhances the strength, temper and appearance of the glass.

U. S. P. 1,271,652/18 Bellamy. Ruby-colored glass is formed from a batch composed of sand 36.3, red lead 36.3, nitrate of soda 16, antimony oxide 1.7, borax 1.7, tin oxide 3.075, potash 4.6, lime 0.3 and 10 carat gold 0.025 part, by heating to about 1300 deg., cooling and reheating to plasticity.

U. S. P. 1,283,606/18 Warga. Decorating glass surfaces by applying colored

design with the aid of a fixing agent consisting of turpentine oil 108, balsam of fir 50, lead acetate 3 and soft flux 1 part, heated to form a syrup.

U. S. P. 1,287,005/18 Handy. A white semi-translucent illuminating glass free from "fire" is formed by fusing together a foundation lead soda batch with aluminum hydrate, and the sulphate, phosphate and chloride of sodium.

B. P. 118,397/18 Corning Glass Works. In making a glass capable of absorbing ultraviolet rays and as nearly colorless as possible, titanium oxide and an oxidizing salt are added. Cerium oxide, etc., may be added, and nitric acid used to prevent reduction of the oxides.

B. P. 118,398/18 Corning Glass Works. In making glass for absorbing ultraviolet rays and as nearly colorless as possible, vanadium in an oxidized form is used. The vanadium may be used with titanium or cerium compounds, manganese oxide, etc. Niter may be added to prevent reduction of the oxides.

U. S. P. 1,303,268/19 Drakenfeld. Amblygonite is added to glass to improve its ease of working and reduce the coefficient of expansion. 1–5% may be added to a basic batch used for making jars, bottles or ordinary window glass, to assist fusion and strengthen the glass formed. In making opaque or translucent glass such as used for lighting fixtures, as high as 50% of amblygonite may be employed, as it assists in imparting opacity. It is especially adapted for making soda, potash, or lead glasses.

U. S. P. 1,303,269/19 Drakenfeld. Spodumene in amounts from 1% to 50% is used as an ingredient in making soda, potash or lead glass. It imparts generally the same properties as amblygonite (see preceding) except as to opacity.

U. S. P. 1,304,623/19 Sullivan. Glasses suitable for making baking dishes and having a linear thermal expansion of less than 0.000004 are formed of silica 70–90, boric oxide 5–20, sodium oxide 0–4.4, alumina 1–6, antimonious oxide 0–1, and lithium oxide 0–3 parts.

U. S. P. 1,305,793/19 Gage. A glass having a high transmission to ultraviolet rays while absorbing practically all visible light, is formed of silica 50%, potassium oxide 16%, barium oxide 25% and nickel oxide 9%. Soda may be used instead of potash and the proportions of the other ingredients may be changed, especially in the case of nickel oxide, which may vary from 0.5 to 12%.

U. S. 1,305,794/19 Gage relates to a similar glass transmitting ultraviolet rays and which may be formed of silica 53–68%, potassium (or sodium) oxide 13.8–2.5%, zinc oxide 14.2–17% and nickel oxide 0.5–12%. Glass containing small amounts of nickel, transmits extreme red and infracted as well as ultraviolet rays but that containing larger amounts of nickel, transmits only ultraviolet.

U. S. P. 1,306,505/19 Ueda. A mat surface is produced upon glass by applying to the surface an adherent mixture of a low-fusing powdered glass mixture with a powdered material which is more refractory and relatively inert, cooling, treating with an ordinary mineral acid, washing and drying. The refractory material may consist of burned porcelain, stoneware, fire-clay, kaolin, chamotte or quartz.

U. S. P. 1,308,426/19 Keil. A semi-transparent material suitable for use as a substitute for glass in interior windows is formed by applying a heavy coating of water-glass in concentrated solution upon wire screening, allowing it to dry and then coating with waterproof varnish.

U. S. P. 1,314,861/19 Eyer. A white clouding material for enamels may be formed by heating zirconium oxide 7 parts, boric acid 3, cryolite 2 and sodium nitrate 5 parts.

U. S. P. 1,319,151/19 Gilligan. A composition for glass molds is formed of powdered graphite, powdered retort carbon and caramelized sugar.

B. P. 125,920/19 Corning Glass Works. Potash boro-silicate glass, containing nickel and copper is used as a filter for artificial light, such as that of a tungsten electric lamp, to produce daylight effects.

B. P. 125,921/19 Corning Glass Works. Potash or lead potash glass containing copper and manganese with or without the addition of cobalt is used as a light-filter in connection with nitrogen filled tungsten lamps to produce daylight effects.

B. P. 127,586/19 Corning Glass Works. In making a practically opaque glass which has a high transmission for ultraviolet rays 0.5–12% nickel oxid is employed in a glass mixture substantially free from lime, magnesia, lead, alumina, and boron oxid. The preferred composition is silica 50, potassium oxid 16, barium 0.25 and nickel oxid 9%. A small amount of cuprous oxid may be added to reduce the transmission of red rays.

B. P. 134,841/19 Kuppers. In making reinforced glass tubes, wire gauze or a wire helix is slipped over a cylindrical core, the glass tube is slid on and the ends are closed. The air is then exhausted and the tube progressively heated, i.e., by an electrically heated ring as described in B. P. 20,192/13, thus causing the tube to collapse upon and unite with the wire. The core is finally removed.

B. P. 143,792/19 Glass. A composition for making molds, dies, cores, plungers, rolls, etc., used in the manufacture of glassware is made of powdered graphite, sulphuric acid, potassium chlorate and mixed with gas-retort carbon and partly carbonized sugar, in a pug-mill. A mixture of caramelized sugar and water is then added, and the whole composition mixed to a stiff paste and pressed to the desired shape hydraulically. Articles produced in the molds, etc., have a surface luster and sharpness similar to cut glass.

U. S. P. 1,328,833/20 Hasburg. In decorative coloring of glass or ceramic ware, a porous foundation coating (such as powdered ocher 4, charcoal 1 part and glucose) is applied to the surface to be decorated and there is then applied upon the coating a coloring material such as aqueous, alcoholic or turpentine mixture, with coloring substances which penetrate the foundation coating, and the coatings are then burned or baked. Copper sulphate may be used in the foundation coating as a coloring agent.

U. S. P. 1,330,611/20 Quimby. In building up rods or tubes of quartz glass a nucleus of quartz glass is heated to a plastic condition, the surface is treated with powdered quartz and reheated to fuse and vitrify the added quartz and the entire mass is then elongated to compensate for the added material.

U. S. P. 1,344,141/20 Meth. Ruby glass is made by mixing antimony sulphate and crude tartar with the ordinary ingredients of transparent glass.

U. S. P. 1,344,686/20 Fully. A mixture formed of corn syrup 66, water 33, bicarbonate of soda 0.1 and cinnamon 0.9 part is used for coating glass to prevent the formation of drops of moisture on it.

B. P. 146,473/20 Rosenthal. By exposure to the action of X-rays or the like, glass is given tints similar to those produced by prolonged exposure to sunlight. This glass is suitable for the manufacture of spectacle lenses.

U. S. P. 1,365,797/21 Smith. Glass made from a batch composed of the following ingredients in approximately the proportions stated: 60% of silica, 10% of boric oxid, 7% of alumina, 9% sodium nitrate, 1% of arsenic trioxid, 3% of calcium carbonate and 10% of sodium carbonate.

Brazil P. 1,366,101/21 Rietz. The manufacture of white, clouded glass, enamels and glazes, which comprises forming glass, glaze or enamel rich in silica and adding thereto unpurified clouding materials and material containing fluorin sufficient to prevent discoloring.

U. S. P. 1,369,988/21 Sullivan and Taylor. A glass containing silica, soda, and at least one of the bivalent alkaline earth oxids, in which the molecular ratios fall within the following limits; silica 100, alkali oxid 20-36, and bivalent oxid content 6-36.

U. S. P. 1,394,296/21 Fisher. The process of forming a non-transparent glass which consists in making a mixture of materials containing silica, oxid of boron,

and one or more other oxids of materials precipitable in the boro silicate, heating the mixture to cause fusion of the materials, and modifying and maintaining the temperature to precipitate the precipitable materials according to the degree of translucency desired, the amount precipitated varying according to the amount of heat applied.

B. P. 1,394,973/21 Crossley. A method of manufacturing glass which comprises heating a mixture of vitreous material and a silicate of high fusibility to a temperature between that at which said vitreous material melts and that at which the silicate begins to lose its water of hydration; whereby the silicate is dissolved in the molten vitreous material.

U. S. P. 1,398,014/21 Fulton. An improvement in the manufacture of earthenware which consists in treating a clay body material with caustic soda, sodium silicate and gallic acid.

U. S. P. 1,403,752/22 Enequist. A method of making a glass having a black effect, which consists in fusing a quantity of basic soda slag with a quantity of glass making materials.

U. S. P. 1,408,145/22 Sullivan and Taylor. A glass having a combined silica and alkali percentage composition over 90 and having the molecular ratio of alkali to silica between 26 and 29 to 100 and the molecular ratio of bivalent oxides to silica of between 7 and 10 to 100, and also containing over 1% of alumina.

U. S. P. 1,411,133/22 Taylor and Gage. A glass opaque to the visible light in plates 6 mm. in thickness, and containing about 6% manganese dioxide and one half of 1% chromium sesquioxide.

U. S. P. 1,411,134/22 Taylor. A glass containing manganese-dioxid and an oxygen compound of chromium, which, measured as a sesquioxid, is in the proportion of 6 to 20 parts of such oxide to 100 parts of the manganese-dioxid.

U. S. P. 1,414,715/22 Taylor. A glass of high ultra-violet absorption of good visible transmission, containing substantial quantities of potash, and between 3 and 6% of cerium dioxid.

U. S. P. 1,415,980/22 Bellamy and Sweely. A batch for non-electrolytic glass, comprising approximately 10% whiting, 21% barium carbonate, 3% clay, 52% boric acid, and 14% quartz.

CHAPTER IV

CASEIN PRODUCTS

We have hitherto been considering plastic materials made from materials of mineral origin, with an occasional admixture, it is true, of such fillers as wood fiber, hemp and the like.

There are also many important organic plastic materials, or plastics whose principal ingredients are of animal or vegetable origin. Among these are such substances as casein, gelatine, paper and fiber products, various kinds of resins and gums, notable among them rubber; and also synthetic organic products resembling resins. In the present volume we shall include, of these materials, the casein products.

The utilization of casein for technical purposes presents the somewhat singular feature of an edible substance, of good food value, being applied to general use as a structural material. Instances of this kind are necessarily rare for two reasons. In the first place, since man is somewhat restricted by nature in his capacity for digesting organic materials, foods are not among the cheapest forms of matter. It would be rather a costly thing for example, to build, on any considerable scale, the gingerbread house of the nursery tale. And secondly, foods are for the most part rather perishable, and therefore not adapted for use in which permanence is a necessary requirement. It surely is remarkable that cheese, of all things, should furnish a substance capable of being made into lasting articles of general utility as it is a partially decayed product even when used commonly by us. Cheese consists of casein and fat in about equal proportions, together with varying amounts of moisture.

While casein in this form has, of course, been known from time immemorial, its isolation and application to industrial purposes is of comparatively recent origin. In 1885 Emery Edwin Childs of Brooklyn, New York, took out what appears to be the first patent for the manufacture of plastic masses from casein. Since then the industry has grown to immense proportions both in this country and also in Europe. Germany, particularly, has had a large part in developing a casein product known as "Galalith" of which more is to be said shortly.

Cow's milk contains on an average about 3½ per cent of casein, probably in combination with lime and phosphorus. It constitutes about four-fifths of the total protein of the milk.

In the manufacture of technical casein products it is essential that a material as nearly as possible free from fat be employed. The usual source is skim milk, from which the fat (cream) has been very thoroughly separated preparatory to the manufacture of butter. In the

dairy industry skim milk is a by-product which possesses a certain food value (pig's fodder) but is often run into the sewer. It is now realized by the progressive dairyman that this represents an unwarranted waste. Under suitable conditions he can separate his casein and make it a source of additional revenue. Casein can also be made from buttermilk, though less readily, owing to the presence of larger amounts of fat. The existing market for buttermilk as a food product determines whether or not this pays.

PRECIPITATION OF CASEIN FROM SKIM MILK

There is a considerable variety of methods by which the casein can be thrown down from its solution or suspension in skim milk.

1. Various acids will bring about this precipitation: sulphuric, acetic, phosphoric, hydrochloric, lactic acid, for example.

2. Casein is also thrown down (as "junket") under the influence of "rennet", an enzyme (ferment, catalyst) prepared from calves' stomachs.

3. Milk exposed to the air becomes sour spontaneously, owing to the formation of lactic acid. As is well known, sour milk curdles, a solid cake of casein (together with fat) is then formed.

Of these various processes of curdling the casein, the two which have found wide application technically are precipitation by sulphuric acid (suitable especially in the manufacture of casein glues) and that by rennet. The latter is stated by Stich to be the only method applicable in the manufacture of Galalith.

SULPHURIC ACID PRECIPITATION OF SKIM MILK CASEIN[1]

The fresh skim milk is heated to 120 degrees F. (48.9 degrees C.), preferably in a wooden vat and by direct steam. Commercial sulphuric acid (sp.g. 1.83), diluted by pouring it into eight times its volume of water, is then added at the rate of one pint to every one thousand pounds of milk, stirring continuously. After a few minutes the curd settles, leaving a fairly clear whey. If this fails to occur in a short time, a further quantity of acid must be added. The quantity of acid required depends somewhat on the condition of the milk.

The clear whey is run off, leaving the layer of curdled casein at the bottom of the tank. This is rinsed with cold water to remove excess of whey and free acid. The curd is then dried, first by draining, then by pressing in burlap or better in duck, and finally by grinding it and placing it upon trays in a tunnel heated to not more than 130 degrees F. (54.5 degrees C.) The last stage in the drying (grinding and heating) may be temporarily omitted if the size of the establishment does not warrant the installation of the requisite plant; but in that case, it is necessary that the curd be shipped without undue delay

[1] For many of the data here present the author is indebted to Bulletin 661 of the U. S. Department of Agriculture.

(especially in warm weather) to a central drying plant where these operations are completed.

Cooked Curd. An alternative method, doing away with the necessity of the preliminary drying of the curd, consists in covering with water the layer collected at the bottom of the precipitating vat and heating to about 170-175 degrees F. (76.7 to 79.4 degrees C.) by direct steam. The curd then collects in a semi-fluid, tough, plastic mass. This can be run into barrels where it forms a solid impervious cake. In this form it will keep for days even in hot weather. The cooked curd is shipped to the central drying plant to be ground and dried.

In using the cooked curd method it is essential to avoid excess of acid, since this may prevent formation of the cake.

CASEIN FROM BUTTERMILK

Casein is readily precipitated from buttermilk directly, i.e., without the addition of acid. The lactic acid naturally present in buttermilk (as it comes from the churn, or if necessary, after a period of "ripening") is sufficient to provoke curdling under suitable conditions. The method recommended by the Bureau of Agriculture is to run the buttermilk together with live steam through a steam ejector, maintaining a temperature of 115 to 130 degrees F. The subsequent steps are essentially the same as those described above in dealing with the preparation of skim milk casein.

Skim milk casein can also be curdled by the ejector method, after "ripening" to the requisite natural acidity, and without addition of mineral acid.

The yield, should be about 3 to 3.25 lb. per 100 lbs. of skim milk, and 2.8 to 3.1 lbs. per 100 lbs. of buttermilk.

Skim milk casein being freer from fat, is preferred and therefore marketed at a somewhat higher price than buttermilk casein.

CURDLING WITH RENNET AND THE MANUFACTURE OF GALALITH

According to E. Stich,[1] curdling with rennet is exclusively to be employed in the manufacture of the plastic mass known as galalith.

As already remarked, rennet is a ferment occurring in the stomach of various animals (horse, cattle, sheep, pigs); a species of vegetable rennet is also found in certain plants. It is commonly manufactured from the stomach and pancreas ("sweetbreads") of calves, by chopping the material fine and extracting with glycerine or with salt solution.

Rennet possesses in a high degree the characteristic property of enzymes (organic catalysts) of causing the transformation of very large quantities of the material upon which its action is exerted. It has been ascertained that one part of rennet will curdle nearly three million parts (2.8 million) of milk in forty minutes at 94 degrees F.

For the precipitation of milk by casein it is essential that the formation of lactic acid (by fermentation of milk sugar) be as far as possible

[1] Kunststoffe, 1915, Vol. 5, pp. 145, 158, 171, 185.

prevented. Preferably the curdling should be carried out immediately after separating the cream. But if the skim milk must be shipped from the creamery to the casein factory, the temperature must at all events be kept below 12 degrees C. (54 dgrees F.) during the transportation; the development of the lactic acid bacteria is under these conditions, almost wholly arrested.[1]

Fleischmann gives the following composition of skim milk as it comes from the separator:

Water	90.35
Fat	0.02
Total protein	4.00
Milk sugar	4.70
Mineral salts	0.75

The "mineral salts" are comparatively rich in calcium. This is essential for a good curdling by rennet. The best temperature for precipitation is 41 degrees C. Below and above this the precipitate is too fine and loose.

Stich lays down the rule that the skim milk to be used in the manufacture of galalith must not contain more than at most 0.3% of fat. A good centrifugal separator will reduce the fat down to 0.05% or less. Stich assumes that one must reckon with an average of 0.2%. The lower the percentage of fat the more easily is a clear transparent product obtainable.

Insofar as an opaque product is aimed at, the average skim milk as it comes from the separator, i.e., containing about 0.2% fat, is quite satisfactory, and requires no further purification.

If a very clear product is required (as in making transparent sheets to serve as substitutes for celluloid), greater freedom from fat may perhaps be best secured by repeated centrifuging, with the addition of caustic soda. According to a patent to Miersch and Eberhard it is possible in this way to extract some 30 lbs. of butter from 1000 gallons skim milk, or the residual fat may be extracted with suitable solvents (ether, chloroform, carbon disulphide, acetone and alcohol). But this is liable to prove costly.

Stich gives some interesting calculations as to the number of fat globules present in a given volume of the casein product. He finds, for example, that with skim milk containing 0.1% fat, (corresponding to 4% fat in the casein) there are ten million fat globules per cubic millimeter of the product. Furthermore, a ray of light passing through a thickness of two millimeters (about one-twelfth of an inch), he finds, would meet no less than three hundred and fifty globules in its passage.

He concludes that in order to make a plate of this thickness appear water-clear the fat content of the skim milk would have to be re-

[1] E. Stich gives some rather interesting data regarding the total quantity of bacteria in milk, as follows:

1 cubic metre, immediately after milking, contained 25,000 bacteria; after 24 hours at 25 deg. C., 806,000,000 bacteria.

duced to 0.02 per cent. For plates of greater thickness a still higher degree of purity would be required, and then extraction by means of one or other of the fat solvents would become indispensable.

Casein can be hardened and rendered insoluble by treatment with alum, tannin, or formaldehyde. The first two of these substances, however, discolor the product. Picric acid may also be used, giving an amber-like product.

The hardening agent most commonly employed is formaldehyde. Galalith is a product thus prepared. The hardening bath is contained in brickwork tanks lined with asphalt. It is essential to keep the liquid circulating and of constant strength. If the hardening is incompletely carried out the product is brittle and an entire batch may have to be discarded. The time required for the hardening process depends on the size (thickness) of the articles, or their water content, and also on the strength of the bath. For example, plates two millimeters thick, require about ten days. The strength of the bath can not very well exceed 35% without causing serious inconvenience to the workmen, owing to the pungent fumes of formaldehyde. With good ventilation the use of a 42% solution is practicable. The use of formaldehyde vapor in place of solution has been tried, but has not been introduced on a technical scale.

Nothing very definite is known regarding the nature of the action of the formaldehyde on the (insoluble) casein precipitated by rennet. What is known, by experience, is that only after such treatment does the casein acquire the requisite properties of elasticity and hardness.

USES OF CASEIN

As has already been indicated, casein possesses properties rendering it applicable for a variety of uses. We will briefly consider some of these in turn.

1. Plastic Masses. Casein, in the form of galalith or related materials, finds applications in the manufacture of a large variety of so-called "novelties"; such as combs, backs for brushes, buttons, ornaments turned on the lathe, piano keys (which unlike ivory, do not become yellow with age) artificial tortoise shell and meerschaum. It is also a fairly serviceable electrical insulator. A plate two millimeters (1/12 inch) thick is proof against 16,000 volts.

The specific gravity of galalith is 1.32 to 1.35 (compared with celluloid 1.34 to 1.40). Its hardness is about 2.5 (celluloid 2.2). It is resistant to oil, alcohol, ether, benzene and acids. It is attacked by alkali which causes it to swell. Its greatest drawback, however, is that it is very hygroscopic and not resistant to water, thus for instance in twelve days it takes up water to the extent of 30% of its own weight. It is also inferior to celluloid in the matter of flexibility. It breaks even on comparatively slight bending. It also is not as well adapted as celluloid to being formed into sheets and films.

There is another class of plastic masses, in which casein functions as a binder, in the presence of various fillers, such as sulphur, sand,

cork dust, oxide of zinc or lead. Such compositions are commonly made from the solution of casein in alkali, and find application for picture molding, toys, etc. A composition of red or white lead and cheese has, by the way, long been used by plumbers as a cement.

Casein has also been made an ingredient of compositions of the celluloid type. It can be incorporated with celluloid, which becomes somewhat less inflammable in consequence.

CASEIN GLUES

A very good glue is made by stirring up casein with distilled water and a little sodium bicarbonate, with or without the addition of shellac. In the woodworking trades casein offers special advantages, being superior to the older gelatine glue in that it does not require to be melted by heat. It is also essentially waterproof, and can be used for delicate work to which ordinary glue is ill adapted.

A variety of recipes for making casein glues have been given. Rogers recommends the addition of 14% borax in hot saturated solution, to dry casein which has been soaked over night in its own weight of water.

Razous recommends, as a cement for crockery, casein dissolved in lime water, to be used immediately after it is prepared. Glue so prepared, once it has set, is resistant even to steam. It makes an excellent lute for laboratory use, and can even be used for caulking ships. Schutzenberger gives the following formula: To 28 litres of warm water add 1 kg. of 20% ammonia, then 7500 gm. powdered casein and stir until all is dissolved.

CASEIN IN PAPER MANUFACTURE

In the paper industry casein finds application as a size for highly glazed papers, such as must be used for finer effects in halftone illustration. Waterproof paper and cardboard is made by impregnating with casein solution and subsequent treatment with formaldehyde. One of the earliest applications of casein was the preparation of "white slates," which will take ordinary pencil writing, and permit of repeated use, sponging off the characters after they have served their purpose.

Somewhat allied to the use of casein in the paper industry is its use in finishing and mordanting textile goods.

CASEIN PAINTS

The addition of milk to colors used in fresco painting is of very ancient origin. The casein paints now extensively placed on the markets are essentially made of suitable pigments and fillers with a casein glue base. Such paints are sold in tins, which must be kept tightly closed when not in use, otherwise the product spoils.

OTHER USES

There may be briefly mentioned a number of other uses of casein. It is used as a precipitant in fining wines, in which case it has the advantage over gelatine of leaving no residual matter of any kind.

Casein foods have been placed on the market, of which perhaps the best known (or at any rate the one most advertised) is Sanatogen. In the preparation of medicinal products casein is used as an emulsifying agent, for example in cod liver oil preparations. It is also used as the vehicle for a variety of drugs, both organic and inorganic (alkaloids, iodine, mercury, etc.). Casein is also an ingredient of pomades and pastes, from face creams to shoe polishes.

PATENT REFERENCES

CASEIN PRODUCTS

U. S. P. 945,294/09 Thoma. For a shoe bottom filler a gelatinous material such as albumen glue, casein glue, starch glue, marine glue, five parts; glycerol 3, stearic acid 1, semi-solid resinous petroleum residue 7, rosin 2. Other ingredients may be pontianak, gutta percha, tuna, viscous oils, cork dust, etc.

B. P. 412/09 Goldsmith. Making casein and like compounds by incorporating a converting agent in the casein which is then treated with an indurating agent to prevent sticking to the mold.

B. P. 13,601/09 Schutze. Making solid plastic material from milk curds by forming a cold water paste, boiling for 5–10 minutes, stirring until pulpy, then pressing into molds, and immersing in formalin in the usual manner.

U. S. P. 959,358/10 Isaacs. Adhesive or sizing, consisting of rennet casein 100, sodium fluoride 15, sodium biborate 15, water 400.

U. S. P. 962,498/10 Dunham. A paper coating and sizing composition consists of modified, non-acidulous wheat gluten 25 and glue or casein 75 parts.

U. S. P. 964,964/10 Goldsmith. A thermoplastic compound is formed by combining casein, formaldehyde and betanaphthol and heating and pressing the resulting mass. Instead of beta-naphthol, alpha-naphthol, benzoic acid, phenol, hydroquinone, cresol, pyrocatechol, resorcinol, salicylic acid, urea, phthalic acid, phloroglucinol, pyrogallol, aniline, toluidine or xylidine may be used.

B. P. 870/10 Peters. A coating for waterproofing articles consists of calcium or barium carbonate and zinc sulphide, with or without barium sulphate, admixed with sodium casein and methyl aldehyde.

B. P. 21,750/10 Barteld. In making elastic horny bodies, powdered casein is mixed with as little water as possible, and under high pressure, while heating, and is formed into plates, rods, and other shaped pieces.

G. P. 253,519/10 Noerdling. Addition to 252,705. A caoutchouc-like product is made when castor oil 100 parts which has been treated with air for 12 hours at 150–200 deg. is stirred, with gentle warming, with 30% formaldehyde 15, concentrated hydrochloric acid 5, and casein 30 parts, and heated at 95 deg., then washed with water and dried.

U. S. P. 984,539/11 Chavassieu. Making soluble and coagulable protein compositions for threads, films, etc., by subjecting a protein substance, e.g., casein, 1 kg. to the action of 3 kg. of a 3–11% solution of an alkaline sulfocarbonate to form a viscous solution. The viscosity of the resulting solution may be increased by adding 200–500 gm. of a 1% solution of caustic soda. Ammonium nitrate and dilute acids are used as coagulants.

U. S. P. 1,000,425/11 Melzer. Making solid colored bodies in imitation of wood, stone, etc., by squirting on an elastic foundation (wire or rubber) superposed layers of compositions of different colors, drying and polishing. Colored mixtures of paper pulp and casein may be used.

B. P. 8,318/11 Bartles. In the manufacture of artificial horn from casein, the hardening agent is added to the casein and the mixture is kneaded and pressed.

B. P. 14,266/11 Timpe. The albuminous constituents of milk are decomposed by adding a pyrophosphate, and after removing the precipitate, the albuminous compound remaining in solution is precipitated by acids, etc. It is then converted into a plastic mass by kneading with ammonia or other alkali and allowing the product to stand in a closed vessel. The material obtained can be converted into threads which are hardened by formaldehyde.

G. P. 251,259/11 Labbe. In making an incombustible celluloid substitute from

albuminous substances such as gelatin and casein, sufficient freshly prepared silicic acid solution is added to form a silicate jelly, and then glycerol is added to the gelatinous product.

G. P. 254,992/11 Stein. A non-combustible celluloid substitute is composed of gelatin 30 kg., dissolved in water, gallic acid 1 kg., casein 30 kg. with corresponding ammonia, 2 kg. of a solution containing caoutchouc 10 parts carbon disulphide 20, and sulphur 2, with some glycerine, and 40 kg. powdered colophony dissolved in an equal weight of aqueous ammonia. The dough is compressed, dried, softened with 20% formaldehyde solution, dried, and is used for making various articles.

U. S. P. 1,023,022/12 Lebreil. Making imitation horn, shell, etc., from casein and acetone.

U. S. P. 1,027,122/12 Goldsmith. Thermoplastic composition formed from casein, formaldehyde and beta-naphthol.

U. S. P. 1,036,405/12 Zuckmayer. Compound formed by the reaction of ferric chloride, sodium caseinate, phosphoric acid and arsenic acid.

F. P. 455,843/12 Chanard. In making plastic celluloid substitutes, resins (such as sandarac) are heated with aqueous soda solution and kneaded with naphthol, albuminous material (casein) is added, followed by compounds having a hardening action, such as peroxides, aldehydes, etc. By adding Canada balsam, transparent masses are obtained. The hardness is increased by the addition of antimony or tin salts.

G. P. 264,567/12 Stephan. Addition to 240,249. In making decorated casein products, the process of the principal patent is extended in its application in that differently colored alkali caseinate solutions are conducted into a precipitating bath of formaldehyde and alkaline earth salt, or are poured upon a backing which is placed in the bath.

G. P. 275,160/12 Wolff & Co. Plastic casein masses are formed by grinding, e.g., 20 kg. colloidal tri-calcium-phosphate-casein in a ball mill with about 8 liters water to which some aniline dye has been added. The pulverulent mass is filled into molds and pressed strongly, the resulting articles being hardened in formaldehyde.

B. P. 12,142/13 Plinatus. A plastic composition, resembling horn, ivory, or ebonite, is made by mixing albumens, such as serum or egg albumen or casein or conversion products thereof, with an ester of a polyvalent alcohol of the fatty-acid series or derivatives, such as the acetins or other esters of glycerol or polyglycerols. The esters of tartaric, lactic, glycollic, hydroxybutyric, formic, or acetic acid may be used, or those obtained by esterifying lactones, or anhydrides of the alphahydroxy acids. Other substances, such as fats and oils, or sulfuretted oils, resins, pitches, paraffins, camphor, cellulose derivatives, or caoutchouc, may be added. The mixture or finished product may be treated with hardening substances such as aldehyde, tanning substances, or chromium compounds and coagulable albumens may be coagulated by chemical or steam treatment. Filling and coloring substances, such as metals, salts, asbestos, pumice, infusorial earth, and silica may also be added.

G. P. 260,200/13 Bernstein. In making a strong casein glue, 100 gm. casein are softened for a long time in cold water, 6 gm. pulverized colophonium are added, while heating and stirring. Free alkali or an alkaline salt is added, until a colloidal solution of the casein resinate results.

G. P. 280,648/13 Kuhl. A soluble resinous product is made by softening 250 gm. granular crude casein in 500 gm. cresol, working up the mass with 400 gm. formaldehyde, and heating in an autoclave up to 3 atmospheres. This pressure is maintained for 10 minutes, when the heat is shut off and the mass allowed to cool.

G. P. 281,235/13 Hoffmann. In evaporating and drying calcium caseinate solutions, for the purposes of obtaining a non-dielectric powder, 10% aqueous caseinate solutions are conducted, drop-wise, through the drying chamber counter to a current of air.

Dan. 18,160/13 Petersen. In making an adhesive, casein is mixed with a porous material such as chalk, infusorial earth, dyes, etc., in order that the casein particles may not come in contact with each other. The mass, upon drying, does not bake together, and may be more easily ground up and dissolved.

U. S. P. 1,141,591/14 Ujhaze. Building block is made of sawdust, with a binder formed of lime, borax and casein and fatty constituents of milk.

B. P. 1,016/14 Petersen-Hviid. A casein product which, when dry, is easily powdered and readily soluble in alkalies, is obtained by mixing wet curd or milk with infusorial earth, and drying. It is intended for use as a binding medium for colors.

Can. 154,062/14 Alder. In making plastic masses, casein 5 kg. is worked into a thick sludge with ammonia, and there is added oxycellulose dissolved in the least possible amount of strong ammonia. After thorough mixing the transparent mass is shaped by heavy pressure and the products are hardened by formaldehyde, dried at a low pressure until transparent and then heated, for 2–10 hours, at 60–80 deg.

Aust. 4,399/14 Roder-Bruno. Addition to 63,556. In making artificial sponge, instead of a cellulose derivative a casein made plastic by alkali solutions, or a similar albuminous material, is mixed with fiber and readily soluble material, and this mixture is treated with a formaldehyde solution or other substance which renders the albumen insoluble, and then the soluble substances are removed.

U. S. P. 1,132,687/15 Ryan. Waterproofing textile fabrics, papers, etc., in web form by successive treatment of the fabric with glue or casein and formaldehyde.

U. S. P. 1,159,878/15 Thomas. Varicolored spherical casein masses are formed by allowing several differently colored streams of alkali caseinate to fall vertically in the form of drops, to a common point in a solution containing formaldehyde and calcium chloride or other alkaline earth salt. The particles obtained are used to imitate horn, etc.

U. S. P. 1,159,987/15 Thomas. Small casein spheres are obtained by pouring an alkali caseinate into cells or chambers formed in a coagulating solution (e.g., magnesium chloride or calcium chloride and formaldehyde). Rough blanks for buttons, beads, etc., are obtained.

B. P. 13,203/15 Bartels Swiss 72,635/16 Bartels and U. S. P. 1,200,539/16 Bartels. In making transparent horn-like masses of casein, the casein is freed from fat by prolonged agitation with a hot fat-solvent, the solvent is removed, and the casein is dried and worked up in the usual manner; suitable solvents are alcohol or mixture of alcohol with benzine or benzene.

G. P. 293,510/15 Scheel. Casein plates are united by interposing between the unhardened and undried plates a layer of moistened pulverulent casein, and heating under high pressure. In this manner plates may be made with varicolored surfaces, e.g., dominoes in black and white, and with very thin layers, imitation ivory.

U. S. P. 1,167,434/16 Reuter. Buttermilk is treated with a solution of sodium carbonate and sodium formate, filtered, and sulphuric acid mixed with formic acid is added to the filtrate, the precipitate is washed with dilute formic acid, dried, ground, and mixed with lime or borax to prepare it for use as a glue or in paints.

U. S. P. 1,189,841/16 Lebreil. Skim milk is heated to 35 deg. C., rennet is added and when coagulation begins the temperature is raised to 75 deg. and afterward maintained at about 15 deg. for 12 hours.

U. S. P. 1,192,783/16 Isaacs. For an adhesive and sizing mixture, casein 100 is mixed with slaked lime 12, turpentine, camphor oil or pine oil 0.25–0.75, sodium fluoride 5 and Portland cement 10 parts.

B. P. 102,375/16 Kohner. Hornlike bodies are made from albumens such as casein by blowing atomized water into a whirling mass of the fine particles, and compressing while hot.

Aust. 72,179/16 Herwisch. Gaskets and the like for use with high pressure

steam are formed of sheets made of asbestos pulp sized with casein to which is added varnish or fat, and also a lubricant such as talc or graphite for increasing the flexibility.

Aust. 72,603/16 Barrett. Waterproof covering for floors, etc., is made of wool felt, impregnated with a pitchy mass, treated with a ground layer of a casein solution and pulverized slate, and then coated with a mixture of "Gloss Oil," and pigment or filling.

Dan. 21,615/16 Soncini. Casein is obtained when lactic acid bacteria are added to skimmed milk, and the milk is curdled with yeast at 40 deg.

U. S. P. 1,231,921/17 Lundberg. Briquets for house building are made of clay and moss, straw, chaff or other fibrous material with water to form a plastic mixture; are dried until they become hard and are then impregnated with a mixture formed of alum 8, horn glue 2, caseinate 3, ocher 6, chalk 6, and water 20 parts, and after drying are coated with water-glass.

U. S. P. 1,239,766/17 Brownell. Curds or wet casein are heated to 57–82 deg. to render the material plastic, sticky and homogeneous. It is then formed into strips or ribbons, immersed in water to render the surface non-adhesive, cut into smaller pieces and dried while being agitated.

U. S. P. 1,240,816/17 Brownell. Casein is dried by heating it until it becomes a plastic adhesive mass, preferably at 60–80 deg., and is then passed under pressure through a heated tube and allowed to emerge into the open air.

U. S. P. 1,275,042/18 Kirkshbraun. A material for making friction-facings for brake linings, etc., is formed of asbestos fiber, a colloidal filler such as clay, glue, casein or soap and a bituminous binder.

B. P. 115,439/18 Weiss. Horny masses are produced from casein, etc., by kneading under heat and pressure with sulfuretted fatty acids, such as Turkey red oils obtained by the action of sulfuric acid, sulfonic acids, etc., on fat oils such as olive or castor oil or on fatty acids.

U. S. P. 1,293,191/19 Pontio. A composition for making doll heads or other molded articles is formed as follows: Casein 10 parts is dissolved in an aqueous alkaline solution together with gelatin 10 and gum arabic 2.5 parts, mixed with a white mineral powder such as talc, plaster of Paris, Spanish white or Meudon white, and the mixture is molded and then hardened in a bath of formaldehyde solution.

U. S. P. 1,347,845/20 Dunham. A stable solution of casein suitable for use as a sizing or adhesive is formed by dissolving boric acid in a hydrofluoric acid solution, adding caustic soda, then adding casein and agitating and heating.

CHAPTER V

PLASTICS IN ROAD CONSTRUCTION

If, after what has been said in the previous chapters, any further example is needed of the limitless variety of applications to which plastic materials are adapted, such example is strikingly presented to us in their use for road construction. Every beaten track, though its constructors were mere wild animals, is an instance of a road molded to shape out of earth or loam. Most primitive roads were presumably of precisely this character, and even in comparatively late times—that is to say until the days of Tresaguet, Telford and McAdam at the end of the eighteenth century—there had been little improvement beyond the most rudimentary stages of road construction in Europe or America. For the wonderful Roman roads extant at that time and even to-day in England and France, were of course, survivals of a forgotten art, an art the importance of which seems to have been but very poorly realized by the people of the middle ages and more recent times. Even the Romans built their highways chiefly for military reasons. To the Caesars it was a matter of supreme importance to be able to throw their armies with expedition and precision to any troubled region of their far-flung domain. And while we give unstinted admiration to the stately causeways that cross the erstwhile Roman Colonies, turning aside neither to the right nor to the left from their bee-line course, it must be said that from the point of view of modern engineering they certainly do not conform with the fundamental tenets of economics and efficiency. We find structures three and even four feet thick, where, with modern practice, one foot would suffice for the automobile and motor truck traffic of to-day, incomparably heavier than any tax ever placed upon their roadways by the marching columns of the Roman legions, or the light vehicles that accompanied them. As for their undeviatingly straight course, this can hardly have been altogether an advantage even from a purely military point of view. Modern custom is to avoid, if at all possible, any grades exceeding a rise of one foot in thirty. Beyond this it is in all ordinary cases more economical to gain an easier grade even at the expense of a detour. But, of course, in Roman economy the labor item played a very different rôle from that in which it figures in our present social system, since slave labor could be had for the mere cost of sustenance.

In a very broad sense every road is built of plastic materials, since the constituents are laid down on the roadbed and tamped or rolled down to shape. Of plastic materials in a narrower sense a variety find application in the construction of different types of road: Mortar, cement, concrete, bricks, clay, loam, tar, pitch, asphalt, and even rub-

ber, in special instances. Numerous patents have also been issued to inventors of various paving compositions, usually of bituminous base, made into blocks of suitable size. Of the value of such proposed pavements it may be well to reserve one's opinion, although it would seem that the additional expense of making the material into blocks is in itself not a favorable feature in determining the prospects of such artificial paving stones in competition with other materials. At the same time it is of course true that blocks specially prepared from wood, stone, or even concrete have been widely used with much success. They present the advantage that they do not call for so skilled a type of labor as do roads of the macadam and similar types.

We shall leave aside such questions as the preliminary survey, and the selection of the best location of a new line of communication between given points, as falling strictly within the interests of the specialist, who finds the requisite information in works devoted to highway engineering.

In all road construction there are certain features, however, calling for particular attention. In the first place, no roadway, however well built in other respects, can give continued satisfaction unless adequate drainage of the foundation on which it rests is provided and in general a road will require drainage to take care of three separate items: Rain falling on the road surface. Rain falling on contiguous land and flowing towards the road. Ground water seeping into the road foundation.

Foundations. The road rests primarily upon the natural soil or rock, spoken of as the *subgrade*, over which an artificial base, the foundation proper, is laid, and this in turn supports the surface layer or crust of the road. It might appear at first sight as if the road could not in any event be more solid than the subgrade, the natural support under it, and as if nothing were gained by overlaying this with more rigid strata. But it must be remembered that the loads are applied to the road surface locally in very concentrated fashion by vehicle wheels and horses' hoofs. One function of the foundation is to distribute these stresses, so that by the time they reach the subgrade they are spread over an area capable of supporting them. It is evident that the requirements placed upon the foundation will depend, among other things, on the character of the natural subgrade, on climatic conditions, and on the nature of the road surface or crust decided upon. So, for example a road surface built of concrete, if sufficiently heavy, or if reinforced with steel bonds, will often give adequate distribution of stresses when resting directly upon the subgrade, without any artificial foundation. On the contrary, a pavement compacted of individual blocks will only in exceptional cases be capable of supporting traffic when resting directly upon the natural subgrade. In the temperate climate of Florida brick roads have been built directly upon the sand. But this represents an altogether exceptional opportunity.

A number of different types of foundation are available for the construction of country roads which can be enumerated as follows: (1) V-drain. (2) Gravel. (3) Crushed stone. (4) Stone base.

(5) Telford. (6) Portland cement. Other types of foundation are used occasionally, but have not become standards.

ROAD SURFACES

The principal types of road surfaces in common use are the following:

1. Earth and Sand-Clay roads
2. Gravel roads
3. Water-bound Macadam
4. Bituminous surfaces
5. Bituminous Macadam
6. Bituminous concrete
7. Asphalt
8. Concrete
9. Brick pavement
10. Wood block pavement.
11. Stone block pavement.

Earth Roads. These are constructed simply by shaping the surface by means of a road drag or a road scraper drawn along the road by a team of horses, after preliminary work, where necessary, with a plow or other accessories. The simplest form of road drag (and a very efficient one) is made from two halves of a split log tied together by cross pieces into a rectangular frame. The drag is used not only in the first construction of the road, but should also be frequently applied to keep the surface of the road in proper shape. If this matter is properly attended to and the road is well drained, an earth road will render very good service for certain kinds of traffic and will be passable for such traffic at all times of the year. A newly made earth road should, wherever possible, be consolidated with a roller.

Sand-clay roads are constructed in similar manner, but are provided with a surface formed of a mixture of sand and clay which is spread over the crown of the road and worked into it by roller or by the traffic itself.

Gravel Roads: Water-bound Macadam. For details regarding their method of construction the reader must be referred to special works on road construction.

Bituminous Surfaces. The development of bituminous surface dressings for roads has come largely as the sequel to the use of oils and bituminous materials as palliatives employed for dust suppression. Such palliatives, when applied repeatedly, ultimately form a more or less permanent road surface. This use of palliatives is, however, not free from objectionable features. A much more valuable road surface can be obtained by the single application of a bituminous material selected expressly for this purpose. Both the substance employed and the mode of application present considerable variety. As to the former, they comprise asphaltic oils, asphalts, crude and refined gas tars,

and combinations of refined tars and asphalts. An essential requirement for a successful material in this use is that it should set sufficiently hard in a short time (24 to 48 hours) to permit of the passage of vehicles without the formation of any perceptible track. The application of ½ gallon per square yard, followed by a thin cover of coarse sand, fine gravel or stone chips has been found effective.

After the road is thoroughly brushed free from dust the bituminous material may be applied to it either from hand pouring cans, or from a distributor with gravity feed or pressure feed. The surface is preferably rolled after the coating has been applied. Where traffic is heavy, a second coating may be applied.

Bituminous Macadam. This term is given to road surfaces prepared by the "penetration method," i.e., by applying a liquid bituminous composition to a previously laid down course of broken stone. The details of the operation are capable of considerable variation, thus two applications of bituminous material may be made, with an intermediate layer of stone chips put down between the two treatments but the general principle underlying all these variations is the laying down of two or more courses of broken stone, chip or the like, alternating with the application of a bituminous liquid.

Bituminous Concrete. This differs from structures described as "bituminous surfaces" in that the ingredients of the concrete are mixed before they are laid down on the road, whereas in the case of the formation of a "bituminous surface" the mixing is effected *in situ*.

Sheet Asphalt. This is a bituminous concrete in which the mineral aggregate consists of fine material, such as sand, limestone dust, Portland cement or the like.

Rock Asphalt. Limestones and sandstones impregnated with 7 to 14 per cent of asphalt occur in a number of localities both in Europe and the United States (California, Kentucky, Oklahoma, Utah). Such rocks are ground to powder, heated to about 200 or 250 degrees Fahrenheit, spread over the road foundation, and rolled and tamped down. If the rock contains over 9 per cent of bitumen, and the rock alone gives too soft a surface, stone dust may be added to give the product the right consistency.

Bituminous Blocks. Paving blocks are made both of bituminous concrete and also of asphalt. There is a certain advantage in the use of such blocks, in that they do not require skilled labor in laying the pavement, whereas the construction of a sheet asphalt surface is a process which demands special skill.

Concrete Roads. Among the various uses to which Portland cement is by nature adapted, not the least important is its application to road construction. Its great strength and toughness are here put to the most severe test, and particular care must be exercised in the selection and mixing of the ingredients of a cement concrete intended for this use. The cement must be of indubitably high and thoroughly uniform grade in order to ensure uniformity in wear; the sand should be clean, containing at most 3% of foreign materials such as clay, and

should be practically free from vegetable acids. Preferably it should be composed of a mixture of coarse and fine grains, as this gives the smallest percentage of voids. The coarse aggregate may consist of gravel or of crushed stone, preference being given by some engineers to the latter, as it is claimed that the angular fragments secure a better bond with the cement. As to the character of stone employed, limestone appears to possess a certain superiority over others, at any rate so far as the liability of the product to crack-formation is concerned. The water used in mixing the concrete must be reasonably clear and free from alkalies, acids and vegetable matter. As to the proportion of the ingredients Moorefield and Voshell[1] make the following recommendation: "Experience has shown that when first-class sand is used very good results are obtained by using a proportion of 1 part of cement to 1½ or 1¾ parts of sand and making the proportion of coarse aggregate such that the resulting concrete will contain slightly more mortar than is sufficient to fill all voids. If a well-graded gravel is used as coarse aggregate, the proportion should be about 1:1½:3, while in most cases where broken stone is used as coarse aggregate it will be found desirable to make the proportion about 1:1¾:3, and in some cases where the particles of stone are of uniform size, even a still greater proportion of mortar will be required, but this should be effected by decreasing the amount of coarse aggregate and not by further increasing the amount of sand."

The concrete may be laid down in one or in two courses. The latter plan may, in certain cases, effect an economy, since the lower layer, not being exposed to the wear of traffic, may be made of somewhat inferior material. But generally speaking all advantages seem to be in favor of the one-course method. The operation is simpler and there is no danger of the wearing surface becoming separated from the lower portion of the concrete.

The subgrade upon which the concrete is laid may be made either flat or crowned. It has been found however, that the flat construction makes a roadbed less liable to form longitudinal cracks. The surface of the subgrade should be as smooth and uniform as possible, in order to furnish opportunity for a certain movement of the pavement when contracting or expanding over it under the influence of changes in weather.

Very thorough mixing is essential, since on it depends uniformity of wearing qualities of the road surface, and also, probably, freedom from cracks on aging. The subgrade should be thoroughly sprinkled with water before laying the concrete upon it, otherwise some of water of the concrete will be absorbed by the dry subgrade. After the concrete is spread in place, the proper cross section is given to it by striking it off with a strike board conforming approximately with the cross section of the finished road, but arched a little more strongly at the crown. The final shape is given to the surface by tamping with a long tamper stretching across the road and operated by two

[1] Office of Public Roads, Bulletin No. 249.

men, one standing on each side of the pavement. The concrete surface must not, of course, be stepped on at this stage.

The surface is finally finished by going over it with floats, the workman standing off on movable bridges placed across the pavement.

In order to provide for expansion and contraction with changes in the weather, joints must be left in the concrete surface. Transverse joints may be placed every 25 or 50 feet apart. Longitudinal joints are desirable if the width of the road exceeds 20 feet.

It is important that the right conditions be provided during the setting of the concrete. As soon as possible after the concrete has been tamped it must be covered with canvas which is sprinkled until thoroughly wet. This wet covering is kept on for about 24 hours, by which time the concrete is usually set sufficiently hard to permit workmen walking on it. The canvas is then taken off and the surface is covered with a two inch layer of earth. This is kept continually moist for about two weeks; it can then be removed and the road is opened for traffic.

Metal reinforcement (wire netting) for concrete roadways has been tried, and seems to afford good protection against the formation of cracks. However, such reinforcement materially adds to the first cost, and makes repair work difficult.

Block Pavements. Block pavements constructed of natural stone (granite) or else of wood do not involve the use of plastics, except incidentally as filler for the joints. Both cement mortar and various bituminous binders have been employed for this purpose. Standard pavements made from plastic materials are: Paving bricks, bituminous concrete blocks, cement concrete blocks. A number of paving blocks made from a variety of substances have recently been patented.

Paving Brick. Paving bricks are made chiefly from shales and fire-clays. The use to which they are put obviously demands exceptional toughness, hardness and uniformity of product, the last mentioned requirement in order to ensure even wear. The best foundation for a brick road surface consists of a course of concrete over which a sand cushion is spread; on this, in turn, the bricks are laid. Transverse expansion joints filled with a bituminous filler may be made every 25 or 50 feet, and a longitudinal joint is made along the curb. The joints between the individual bricks may be filled with a bituminous filler or with Portland cement grout.

Blocks of Concrete, Bituminous Concrete, Etc. Instead of laying down a sheet of plastic material on the roadbed, and allowing it to consolidate *in situ*, the practice has in some cases been followed of molding blocks from suitable plastic materials and putting these down as a pavement. The laying down of such a pavement in general requires less skilled labor and less special plans than the construction of a concrete or similar sheet.

Limiting Endurance of Different Types of Roads. It is difficult to give any very precise indications of the durability of the several types of roads. The following table, drawn up by the American Road-

builders' Association, is perhaps as good a synopsis of the situation as can be given:

DAILY TRAFFIC

ITEM	HORSE DRAWN, STEEL TIRES		SELF-PROPELLED, RUBBER TIRES		SELF-PROPELLED, STEEL TIRES
	Light vehicles	*Heavy vehicles, wagons, trucks*	*Passenger automobiles*	*Motor trucks and buses*	*Steam lorries and tractors*
Earth (sand)	100	75	100	.....	.....
Gravel	100–200	75–150	400 up	.....	1
Cold oil surface treated gravel	100–200	75–150	400 up	10	1
Water-bound macadam (surface treated)	100–200	75–150	100–400	10	1
Water-bound macadam (cold asphalt oil surface treated)	100–200	75–150	100–400	10	1
Water-bound macadam (hot surface treated)	100–200	75–150	400 up	10	1
Water-bound macadam (cold tar surface treated)	100–200	75–150	400 up	10	1
Bituminous macadam (soft stone)	200 up	75–150	400 up	10–20	1
Bituminous macadam or concrete (hard stone)	200 up	150 up	400 up	10–20	2–6
Concrete	100–200	75–150	400 up	10–20	.....
Vitrified brick stone sets or wood block	200 up	150 up	400 up	20 up	6 up

The Bureau of Public Roads gives the following list of road surfaces, arranged in order of merit in point of service value:

Brick on a concrete base.

Sheet asphalt on a concrete base.

Cement concrete.

Bituminous concrete on an adequate base.

Bituminous macadam.

Surface-treated macadam.

Water-bound macadam.

Gravel macadam.

Gravel.

Sand-clay.

Top soil.

Earth.

A somewhat more detailed classification of roads according to their adaptation for different types of traffic is given by E. W. James in *"Public Roads"* June 1920, p. 32, as follows:

Class A for heavy traffic:

(1) Monolithic or semimonolithic brick pavement using 3-inch or 3½-inch block on cement concrete base, 4 or 5 inches deep, 1–2½–5, or 1–3–6 mix.
(2) Bituminous concrete, 2 inches thick, on a 6- or a 5-inch cement concrete base, 1–3–6 mix.
(3) Cement concrete pavement, 6 inches thick at the sides and 7½ inches at the center, 1–2–4 mix.

Class B for medium traffic:

(1) Bituminous concrete, 1½ inches thick, on a cement concrete base 4 to 5 inches thick, 1–3–6 mix.
(2) Cement concrete pavement, 5 by 6½ inches, 1–2–4 mix.
(3) Bituminous concrete, 2 inches thick, on a 4-inch bituminous concrete base of crushed stone or gravel.

Class C for light traffic:

(1) Bituminous concrete, 1½ inches thick, on a bituminous concrete base, 4 inches deep, of crushed stone or gravel.
(2) Bituminous concrete, 1½ inches thick, a bituminous binder course 1½ to 2 inches thick, on a 4-inch broken-stone base.
(3) Bituminous concrete, 2 inches thick, on a water-bound macadam base 5 inches thick.
(4) Bituminous macadam, 2½ inches thick, on a 5-inch water-bound macadam.

Summary. The principal characteristics of the several types of road surfaces and pavements are summarized below in tabular form.

Type of Road	*Type of Traffic to which best adapted*	*Foothold*	*Resistance to Traffic*	*Noisiness*	*Dustiness*	*Muddiness*	*Other Features*
Asphalt	Heavy horse-drawn and automobile. Moderate heavy truck traffic	Fair; slippery when wet	Very low	Noisy for horses' hoofs. Noiseless for vehicle wheels	Low	Low	Easily cleaned, sanitary. Too smooth for grades over 3.5%. Easily repaired. Injured by gas leaks
Portland cement concrete	Same as bituminous concrete, but will stand heavier loads	Good	Low; somewhat slippery in wet weather	Considerable	Low	Low	Liable to form cracks, also to uneven wear, unless thoroughly well made. Objectionable glare in sunlight, unless coated with bituminous surface
Brick pavement	Same as concrete	Fair	Low	Moderate if joints filled with bitumen; noisy if grouted	Low	Low	Easily maintained and kept clean. First cost high. Not as durable as stone blocks, but smoother riding
Wood block pavement	Heavy traffic of all kinds	Very slippery at times	Very low	Very low both to hoof and wheel	Low	Low	Very durable if treated with good preservative, though less durable than brick. Easily cleaned and sanitary when well laid
Stone block pavement	Heaviest traffic of all kinds	Good	Moderate	High	Low	Low	
Rubber	Light traffic	Good when dry	Low	Nil	Low	Low	Cost prohibitive for all but exceptional use (e.g., driveways near hotels)

Type of Road	*Type of Traffic to which best adapted*	*Foothold*	*Resistance to Traffic*	*Noisiness*	*Dustiness*	*Muddiness*	*Other Features*
Earth	In dry weather light volume of all kinds	Good	High	Low	Very high	Very high	First cost lowest of all types
Sand-Clay	Moderate horse-drawn and light automobile. Not for heavy trucks unless roadbed is excellent	Good	High	Low	High	High	First cost low
Gravel	Heavy horse-drawn. Light automobile. Light traffic in heavy trucks	Good	Moderate	Low	High	High	First cost low
Water-bound macadam	Same as gravel. Will not stand heavy auto traffic	Good	Low	Low	High	Moderate or low	
Bituminous surface	Heavy auto traffic. Light traffic in horse-drawn and heavy trucks	Varies; sometimes slippery	Low or moderate	Variable. Moderate or high	Low	Sometimes greasy mud which may soil clothing and attack carriage varnish	
Bituminous concrete	Heavy horse-drawn and automobile. Moderate traffic in heavy trucks	Good; sometimes slippery	Low	Moderate or low	Low	Low	
Bituminous macadam	Heavy horse-drawn and automobile. Moderate heavy truck traffic	Good	Low	Moderate or low	Low	Low	

PATENT REFERENCES

BITUMINOUS MATERIALS AND PAVING BLOCKS

U. S. P. 933,145/09 Weckerly. Composition for railroad ties, posts, etc., made from hard pitch 26, coal tar 26, dead oil 10, crushed slag 65 to 75 parts by volume.

B. P. 18,102/09 Flentje. Artificial paving stone made of 84% calcareous stone with melting point 1300° C. and 16% clay, melting point 950° C. The mixture is rolled and pressed, dried and burned at 1100° C.

G. P. 235,863/10 Asphaltwerke. In the manufacture of cast asphalt blocks the liquid asphalt is spread out in a form to a suitable thickness, and the forms are pressed into this layer.

G. P. 236,239/10 Zuel. Material for street paving, etc., consisting of a mixture of pitch, sulphur, powdered clay, formed into blocks or slabs, which for use are heated to 250°–300° C., and mixed with suitable broken stone.

U. S. P. 984,543/11 Crockett. Paving compound, coal or pine tar 1, slaked lime 1, sand 3, slag or cracked stone 7, and a small quantity of acetic acid.

U. S. P. 1,007,621/11 Womack. Paving material composed of sawdust 34, tar 18, sharp sand 34, cement 5, crude sulphur 5, pine rosin 8 and black strap molasses 9.

U. S. P. 1,007,832/11 Whitney. Making paving blocks by mixing hot stone particles, fine and bituminous cement and subjecting portions of the mixture to successive compression.

U. S. P. 1,007,833/11 Wilkinson. Making asphalt paving blocks. By mixing hot stony material after treatment with petroleum residue, with heat-softened asphaltic cement, forming the material into blocks, compacting under heavy pressure while hot, and cooling in water.

B. P. 19,364/12 Furse. A composition for road making and the like, which may be molded into bricks or slabs, consists of about 80% of a disintegrated material which breaks with a conchoidal fracture, such as flint, gravel, shingle, or quartz, mixed while hot with about 10% of lime, chalk, or clay, and 10% of liquefied bitumen, asphalt, pitch, or the like.

B. P. 19,500/12 Ehrlich. Slabs for paving or road-covering are formed from pitch 40, coal tar 13.5, natural asphalt 30, resin 8.5, Trinidad-Goudron (a mixture of asphalt, tar, and oil) 4, chalk powdered and broken stone 900–950. The stones are heated to about 80°–100° C. and the other ingredients, heated to 150°, are poured over them.

U. S. P. 1,062,686/13 Amies. Making a paving material by agitating paper with broken stone in a mixer until the paper is disintegrated and somewhat balled, then adding a bituminous cement and continuing the agitation to thoroughly mix the mass. Sawdust, sugar-cane refuse or peat may be substituted for paper.

B. P. 10,281/13 Becker. Paving and building blocks are made from fusible domestic and other refuse, by separating it into its coarse and fine constituents, forming the fines into briquets, fusing with coke in a blast furnace, drawing off the iron, and pouring the slag into molds. The filled molds are heated in a furnace which may be fed with the coarse refuse, and the molds and contents finally allowed to cool slowly.

B. P. 24,141/13 Chiapponi. A process of obtaining from furnace slag articles such as tiles, paving-slabs, etc., imitating pottery, consists in fusing slag with the addition of 10–20% iron or manganese oxide or other base, running the molten mass into a heated mold, allowing it to cool sufficiently to set, removing the article and rapidly cooling it in water.

U. S. P. 1,105,905/14 Heslop. Artificial stone for building or paving, formed of sulphur 6%, pine tar 9% and gravel 85%, heated together.

U. S. P. 1,190,615/16 Willis. In making paving blocks, drain pipes, etc., copper sulphate 0.25–1.0, asphalt 10–20 and sand or earth 80–90 parts are mixed while at a temperature of about 115° in vacuo and molded.

U. S. P. 1,193,952/16 Wagner. In making paving or building bricks or building tiles water 35 gals. is mixed with each cu. yd. of a mixture composed of coal ash 99 and crude fibrous asbestos 1% and the product is molded and burned.

B. P. 102,522/16 Gibb. Sawdust previously soaked in water is mixed with Portland cement, with or without sand or small stone chips, in the proportion of not more than 2 parts by volume of sawdust to 1 of cement. The product is used for building and paving blocks or may be laid *in situ*.

U. S. P. 1,220,401/17 Caudemberg. Caoutchouc is dissolved in a mixture of benzol and carbon bisulphide mixed with gas tar distillate, from which the benzol has been removed, added while hot to concrete and the latter then molded under pressure to form paving, building or roofing material.

U. S. P. 1,320,709/19 Popkess. Shaped articles suitable for building roads are formed of aggregate such as sand, gravel, and rock in locking arrangements cemented together by a composition of bitumen and earth or other dust-like mineral matter in such proportions as to constitute a non-flowing but malleable material.

F. P. 390,380/08 Moeller Co. Resistant cardboard and felt for roof covering is made by first impregnating the cardboard or felt with a solution of copper or iron of 5–20% or the like, then passing through the rolls and dipping in a bath of tar or the like.

B. P. 5,925/09 Hiscutt. A composition of coal tar and petroleum oil with sun driers, terebene, or any liquid dryers that will cause the tar and oil when mixed or separate to dry on any road surface.

G. P. 228,961/09 Lycodinwerke. Molding powder of carbonaceous material (powdered coke with coal dust and kieselguhr) saturated with rosins.

U. S. P. 934,494/09 Amies. A paving composition is made when mineral materials, as broken stone or gravel, are coated with a light oil, then mixed with a binder, as hot asphalt, and finally coated with air-slaked lime, limestone or lime powder.

U. S. P. 934,495/09 Amies. Crushed stone and stone dust are coated with light oil, mixed with heavy asphaltic cement and then with lime, the composition preferably being laid before slaking the lime.

U. S. P. 935,180/09 Williamson. In making graphite articles, powdered carbon and a carbonaceous binder, as tar or pitch, are molded, the volatile constituents expelled by heat, the article impregnated by vacuum and pressure with a material yielding a carbonaceous residue, as tar, and graphitized.

U. S. P. 935,572/09 Amies. A composition for binding and surfacing pavements is made of mineral matter, as crushed stone, coated with crude naphtha, gasoline or alcohol, with or without light oils, mixed with hot asphalt cement and finally with sand, the mixture being agitated until cold in order to produce a granular composition which will not adhere unless compressed.

U. S. P. 942,236/09 Amies. A paving composition is made of mineral matter, as broken stone, coated with light oil and then mixed successively with hot asphalt and cream of lime.

U. S. P. 942,237/09 Amies. For paving, coal tar is mixed with crushed stone or the like and lime or slaked lime is combined with the mass.

U. S. P. 945,071/09 Amies. For paving, asphalt oil is mixed with crude petroleum, gasoline and pulverized hard asphalt, the composition being heated after laying upon a foundation.

U. S. P. 945,999/10 Amies. For road construction, soil 84% mixed with lime 6% and asphalt 10% is rolled upon a heavy stone foundation.

U. S. P. 956,009/10 Westrum. Building roads by laying upon a foundation a mixture of asphaltic cement 60–80, emulsified with mineral oil residuum or cotton seed oil residuum 20–40, resin 4–8, resin oil 3–6, red oil 2–4, ammonia 2–4 and water 20–40 parts, and broken stones, gravel, earth, etc.

B. P. 11,908/10 Muller. A material produced by mixing together tar and asbestos, heating to 250 deg. or over, reducing the product to a powder, and then molding or pressing it.

F. P. 416,177/10 Raschig. In coating material with tar, the latter is first mixed with Fuller's earth which has been ground with water. Such an emulsion may be applied to a surface which has not been dried.

U. S. P. 981,225/11 Richardson. Paving cement containing native bitumen, as uintahite, 30, a heavy asphaltic flux, of at least 0.95 sp. gr. 70 and a light flux, as petroleum oil of about 0.86 sp. gr., about 33 parts.

U. S. P. 985,967/11 Bayer. Composition for patterns and match plates, consisting of asphalt 73, plaster of Paris 25 and plumbago 2 parts.

B. P. 4,117/11 Johnson. A composition for making tires consists of wool 8, hemp or flax 2, tar 2, with or without wire, glutinous matter, or resin.

B. P. 4,589/11 Radcliffe. A plastic composition approximating in properties to natural asphalts and bitumens is formed by mixing finely divided wood, cellulose, peat, or like organic matter, with pitch, in proportions up to the point at which the composition becomes liquefiable by heat, with or without the addition of oil.

G. P. 247,501/11 Goepper. Making viscous, stringy, glutinous masses from resins or resinous products for the asphalt industry and the like, by heating fir resin, waste-pitch and the like, with concentrated sulphuric acid at 200 deg., the excess acid being removed from the crude product by dilute caustic soda.

G. P. 253,377/11 Baer. In making plastic masses asphalt or resin, dissolved in petroleum, terpentine, or other solvent not too volatile, is combined with sodium silicate and air slaked lime.

B. P. 16,125/12 Marriott. In making bitumen compounds, kaolinite 33% is added to refined natural bitumen free from clay 66%, producing a compound similar to Lake Trinidad bitumen. By the addition of from 3 to 9% of a suitable flux, synthetic trench and joint-box insulating compounds are obtained.

F. P. 450,758/12 and **G. P. 265,054/12** and **Aust. P. 72,401/16 Goepper.** In making viscous, fibrous, and gelatinous masses, pitch resin and similar residues (100 kg.) are heated or fused with 0.1–10 kg. hygroscopic agents such as calcium chloride, zinc chloride, phosphorous pentoxide, magnesium chloride, or sulphuric anhydride at 200 deg. or with reducing metals, such as zinc or tin, 0.2 to 5 kg. for 3 to 4 hrs. at 300 deg. and then the mass, at 100 deg., is decanted. The product is used in the asphalt industry.

G. P. 267,126/12 Landsberg. In making asphalt-like masses, the resin acids resulting from the refining of heavy mineral-oils with sulphuric acid are treated with an excess of a solvent such as benzine until a resinous residue remains which is soluble in water.

G. P. 275,327/12 Radcliffe. An asphalt substitute for covering floors is made by mixing, for example, pitch 80–90, turf 10–20 and linseed oil or the like 7 parts.

U. S. P. 1,045,982/13 Jeroch. Solidifying emulsions (e.g., roads oils or tar) by the addition of a double salt, e.g., of magnesium and calcium chlorides, so they may again be formed into liquid emulsions by adding water.

U. S. P. 1,077,081/13 Kaempf. Working over old asphalt and similar substances by grinding, mixing with water and a heavy oil to soften and emulsify it, shaping and allowing to harden by evaporation of the water.

B. P. 22,738/13 Davis. A binder for fuel or other briquets, or for road-making, consists of gilsonite mixed with an untreated heavy hydrocarbon oil or tar. Hardening agents such as ferric chloride may be added. E.g., 18 oz. gilsonite and 34 oz. bituminous oil are mixed with 34 lbs. coal. The fuel material may also be small coke, coke breeze, sawdust or other waste substances. A binder for road making consists of 5 parts gilsonite, 92 of bituminous oil, and 3 of iron chloride.

F. P. 460,943/13 Soc. Combustibles. In the manufacture of plastic masses for road making, the constituents of tar which give it a crystalline structure and a caustic nature are extracted, and to the product obtained are added anthracenes and anthracene oil to give it the desired viscosity for use as a road material.

G. P. 276,973/13 Schlisske. From peat there is made a light fireproof building material impervious to moisture and sound by thoroughly drying the turf and impregnating, under reduced air pressure, with tar, asphalt, stearin pitch, with or without the addition of loam, clay, quartz, and the like, also insoluble silicates obtained by the decomposition of alkaline earths, or borates, sulphates, and phosphates, gutta-percha, caoutchouc, and their substitutes. The products may also be covered with plates of cork, or wood, slate, glass, water-tight paper, etc.

G. P. 277,643/13 Binder. In making a coating material for roof paper, jute, fabric, and the like, 50 parts montan wax or residues of the montan wax manufacture, 100 parts stearin pitch, and 100 parts of a suitable earth color are melted together and air is passed through until the bituminous materials are thoroughly colored.

G. P. 284,255/13 Schroter. In making insulating bodies from peat and a binder, such as tar pitch, porous, anhydrous, long-fiber peat is subjected while hot to the action of cold and moist compressed air mixed with pulverulent binder, and then formed in presses.

B. P. 1,805/14 White. A roofing composition is made by mixing 4 parts of calcined silica, while hot, with 1 part of melted natural bitumen. To the hot mixture, 10% of red lead or litharge and 10% of a mixture of sodium and potas sium silicates, are added. It may be spread upon felt or similar material.

U. S. P. 1,155,442/15 Rosen. A plastic material for tarring roads, etc., is made by freeing coal tar from phenols and phenol oils, and from naphthalene and naphthalene oils, mixing the residue of the tar with anthracene and anthracene oils, and passing a current of air through the mixture to thicken it.

U. S. P. 1,156,122/15 Woodley. A bituminous composition for roofing, etc., is made by mixing fibrous material, e.g., waste paper, 20%, with hot residuum oil and asphalt or similar material 80%, allowing the mixture to stiffen somewhat and then pulling it to disintegrate the fibrous material and distribute it uniformly throughout the binder.

U. S. P. 1,158,418/15 Hart. Bituminous road-surfacing material is mixed with alum or other crystallized salt to convert water of emulsification from the asphalt, etc., into water of crystallization and thus improve the water repelling properties of the bituminous material.

B. P. 4,414/15 Studer. Road-surface material consists of broken stone bound together by a mixture of 35 parts of gas tar freed from light oils, 35 parts of Trinidad or other good bitumen, 20 parts of powdered rock asphalt, and 10 parts of blast-furnace slag sand. From 80 to 100 kg. of the hot mixture are mixed with 1 cu. m. of heated broken stone.

B. P. 6,823/15 Van Westrum. In making waterproof material for road surfaces, walls, or ceilings, and for building or fuel blocks, an emulsion of bitumen, such as asphalt, and its distillates, or rock-oil residues, is mixed with a suitable aggregate, such as stones, earth, stone dust, sawdust, hydraulic lime, cements, cellulose, and chalk, and then unslaked lime is added in the proportion of 0.5–2% by weight of the emulsion, for the purpose of separating the bitumen from the

water. When inflammable aggregate materials are used, such as coal, sawdust, or cellulose, blocks suitable for use as fuel may be made.

B. P. 11,331/15 Zimmer. Asphalt suitable for road paving is made from bituminous substances such as natural asphalts, resins, mineral oils and their residues, tar and tar residues and distillates, vegetable and animal oils, by emulsifying, preferably with sulphonated fatty acids of animal and vegetable oils and fats, and then adding powdered limestone or powdered natural rock containing lime. After a short time the liquid is drawn off and the plastic mixture is dried in the air. When heated to 150–200 deg. the product crumbles to a dry powder which may be tamped.

G. P. 294,046/15 Barber Asphalt Co. The sulphur present as a natural constituent in crude asphalts is retained by adding 15–20 kg. of linseed oil, fish oil, or petroleum to 100 kg. of the crude asphalt, the mixture being subjected to the usual treatment for the expulsion of water and the volatilization of other constituents.

F. P. 478,360/15 and **Swiss P. 72,466/15 Westrum.** While making, in the cold, impervious bodies such as roads, briquets, walls, etc., with the use of a mixture containing a bituminous emulsion, the bitumen is dried by the addition of lime.

U. S. P. 1,192,062/16 Hinckley. A mixture of coke and pitch for use in forming furnace electrodes or the like is combined, before molding, with ammonium sulphate in amount equal to 5–15% the weight of the pitch, to facilitate immediate escape of gases and prevent deformation during baking.

U. S. P. 1,198,843/16 Symmes. In flooring, stone chips are covered with sodium silicate or other material impervious to asphalt oils and are then embedded in an asphaltic binder.

U. S. P. 1,206,076/16 Altpeter. A mixture for roofing and analogous uses is formed of asbestos 58, rock asphalt 20, gum asphalt 10, refined tar pitch 10, and ammonium sulphate or aluminum sulphate 2%.

U. S. P. 1,209,238/16 Welsh. A pavement surfacing composition is formed by mixing steam-distilled, petroleum-residuum asphalt from which volatile constituents have been removed, with about 20% its weight of petroleum which has been heated with air under pressure without removing its volatile constituents.

U. S. P. 1,218,218/16 Schutte. A paving composition is made by mixing a heated mineral aggregate with a bituminous binder and then with a non-adhesive powder such as talc, soapstone, serpentine or ground asbestos. For road-making it is treated with a solvent oil which softens the binder, giving a mixture which may be rolled into a solid waterproof road.

U. S. P. 1,239,160/16 Cowell. A paving or road surfacing mixture is formed of maltha 1.75, anthracene oil 15.75, hard pitch 26, gypsum 9.5, chalk 19, magnesium silicate 3, cement 18, acaroid resin 7, and comminuted stone 100 parts.

U. S. P. 1,340,352/16 Popkess. A paving mixture is made from finely divided moist earthy material which is warmed and mixed with liquid bitumen. U. S. 1,240,253 specifies an emulsion of water and clayey earthy material with a limited amount of asphalt.

B. P. 105,202/16 Illemann. A moist and plastic composition that can be rendered fluid merely by adding water consists of bitumen or pitch 5 parts, clay 3 parts, and water 3 parts. The product may be used for coating surfaces or roads, flat roofs, etc., or for making blocks or slabs.

B. P. 105,352/16 Gavin. A composition for coating decks, etc., is made when 11.25 cwt. of mineral pitch is melted with 18 gal. of mineral oil, and 3 cwt. Roman cement, and 28 lbs. Arran lime and 28 lbs. resin are added, the mixture being boiled and cast into 1 cwt. blocks. For use, three blocks are melted, and 5 lbs. cork dust and 14 lbs. light silica are added. An under-coating may consist of equal parts of carbon pitch, and resin dissolved in mineral oil.

B. P. 107,613/16 Moniwa. A cement for joining smooth surfaces, like tiles, consists of 20–25 parts bitumen, 14–17 parts asphaltine and 66–58 parts quartz and asbestos. Bitumen is defined as that part of asphalt soluble in carbon bisulphide and kerosene, while asphaltine is insoluble in kerosene.

F. P. 479,197/16 Barber Co. An artificially prepared bituminous cement, for paving, comprises a bituminous substance to which has been added a colloidal solid material, such as fine clay previously mixed with water.

Swiss P. 73,802/16 Torf-Insolation Ges. In making an insulating material, peat and a binder are mixed cold, then heated to cause fusion of the binder. Pitch, tar, resins, asphalts, and the like may be used.

S. P. 71,890/16 and **U. S. P. 1,237,852/17 Zimmer.** Synthetic asphalt limestone is formed when water emulsions of bituminous substances are made with sulphonated fatty acids and allowed to act on pulverized rock, the excess liquid removed, and the resulting product heated to 150–200 deg. C.

B. P. 120,961/17 Ross. A material for surfacing roads is made by mixing preferably 100 parts of earthy material, such as loam, soil or clay, with 35 parts of water to form a thin mud, and adding 20 parts of asphalt, natural bitumen, or coal-tar pitch, or other artificially prepared pitch, and 1 part of a solvent for the asphalt, etc., such as dead oil, cresol, or crude carbolic acid.

B. P. 123,101/17 Goldreich. Textile material such as cotton, or paper, etc., is waterproofed by impregnating with gilsonite mixed with petroleum jelly, or wool fat, and with an oil such as linseed. Eucalyptus or other antiseptic oil may be added and pigment of suitable color.

Can. P. 174,869/17 Corness. A paving composition is made of a mixture of bituminous pitch and heavy bituminous hydrocarbon oil with a base of gypsum, chalk and magnesium silicate.

F. P. 482,145/17 Moniwa. Asphalt is mixed with one or more mineral substances (pulverized quartz, asbestos, etc.) which are infusible, in such proportions that the hardness and the coefficient of expansion of the cement may be practically the same as those of the substance with which it is used.

F. P. 484,258/17 Caudemberg. A paving composition of asphalt and bitumen with rubber is prepared with the aid of solvents obtained by adding to benzene or toluene, tetrachlorethane in the proportions of about 20% for operating in the cold, and 86% for operating with heat.

Jap. P. 31,626/17 Komakura. In making asphalt tile, air is forced through a mixture of asphalt 10, cottonseed oil 5.5, hemp oil 4, coal tar 4, soot 1 and sulphur 2 parts. To the product is added mica powder of 150 mesh 13, sand of 50 mesh 12, sand of 80 mesh 8 and gravel passing through 0.2 mesh 35 parts.

U. S. P. 1,253,454/18 Abraham. A composition for repairing roofs, etc., is formed by mixing waste bituminous roofing felt, or other bituminous material containing about 10% of non-mineral fibrous material, with about 20% of a volatile solvent and about 20% of powdered non-fibrous mineral material, e.g., clay, chalk or talc.

U. S. P. 1,263,823/18 Wallin. Waterproof sheet roofing is formed of comminuted spent tan bark mixed with other reinforcing fibrous material such as hair, rags or asbestos, and saturated with pitch, coal tar, resin, wax tailings or asphalt.

U. S. P. 1,264,943/18 Henderson. A mixture of bituminous residuum of asphaltic base petroleum 90–95% with sulphur 5–10% is used for bonding wood fiber or other materials.

U. S. P. 1,266,261/18 Henderson. A binder for use with wood fiber is formed by mixing coal-tar pitch with petroleum and with 6–14% of sulphur and then heating the mixture to drive off the petroleum.

U. S. P. 1,279,918/18 Savage. Fuller's earth is mixed with asphalt or similar material to render it more rigid and less brittle. Fuller's earth already used in

purifying oils may be employed and the mixtures are preferably highly heated for several hours, with or without addition of sulphur as a vulcanizing agent.

U. S. P. 1,288,159/18 Perry. Finely divided asbestos or other fibrous material is added to comminuted pitch, asphalt or other bituminous substance and while the mixture is in soft adherent condition it is pressed into sheet form.

U. S. P. 1,289,328/18 Wardell. Roofing material, which may be made of saturated felt with an asphalt surface, is coated, while its surface is hot, with particles of grit moistened with an asphalt solvent such as naphtha or gasoline.

B. P. 122,922/18 Jones. An asphalt composition is made of tar which has been thickened by heating (sp. gr. of 1.18 to 1.21) mixed with sand which has been calcined at 104–120 deg. A small amount calcined alumina, silicate of alumina, feldspar, silica, limestone, or crushed granite may be added.

B. P. 125,492/18 Kelsey. A waterproof compound for roofing, etc., is formed in the cold state from 11 lbs. of fiber mixed with 2–5 gal. of tar, or it may comprise 156 lbs. fiber, 36 lbs. silica, 40 lbs. each of crushed magnesium chloride and gas tar pitch and 10 gal. of gas-tar oil. Cotton or woolen cloth or hair, or a mineral fiber may be used.

Can. P. 184,720/18 Sharpneck. A composition for pavement contains a finely divided filler, mineral asphaltum, silica, iron oxide, alumina and sulphate.

Can. P. 187,504/18 Schutte. A wear-resisting material free from dust filler is mixed with bituminous cement having asbestos fiber incorporated therewith.

Swed. P. 44,049/18 Vilen. Ground peat is mixed with powdered resin or asphalt or the like, and the product is heated and molded under pressure. It is used for insulating.

U. S. P. 1,293,293/19 Allison. Roofing scrap containing asphalt and fibrous material is boiled in a 5% alkali solution, and the disintegrated mass of fibrous and asphalt material is removed and rolled into sheets, which are used for heat-insulating or roofing. Additional asphalt may be added before rolling.

U. S. P. 1,296,083/19 Illemann. A mixture of bitumen or pitch 5, clay 3 and water 3 parts is used for surfacing roads, for roofing or in the form of molded blocks for other purposes.

U. S. P. 1,301,612/19 Simpson. A friction facing for clutches or brakes is produced by impregnating an asbestos fabric with a mixture prepared by mixing a hard bitumen with an oil such as linseed oil by melting the two ingredients together and diluting them with a volatile vehicle such as gasoline. Gilsonite may be used.

U. S. P. 1,302,810/19 Kirschbraun. A mixture for roofing, flooring, wall-boards, or other uses is prepared by mixing an aqueous paste of clay with a liquid bituminous material and a filler such as leather waste, paper or wood pulp. If a light-colored product is desired light-colored resins, linseed oil and wax tailings may be substituted for dark bituminous substances such as asphalt or coal-tar pitch.

U. S. P. 1,305,081/19 Elliott. A waterproofed roofing material is prepared by mixing a mass of pulp with small particles of waterproof material such as asphalt, forming a sheet, and treating it with a hot bath of liquefied asphalt or equivalent material.

U. S. P. 1,305,404/19 Perry. Filaments of waterproofing material such as pitch or asphalt are mixed with paper stock, the mixture is formed into sheets and these are saturated with molten bituminous material.

U. S. P. 1,311,862/19 Adams. A sheet of building felt or paper is treated to give it a napped surface and is then treated with asphalt or other waterproofing material.

U. S. P. 1,311,941/19 Abraham. A material suitable for use as a roofing fabric is prepared by saturating a sheet of felted paper fibers and sea-grass fibers with at least an equal weight of a bituminous material.

U. S. P. 1,312,758/19 Spear. A material for inner soles of shoes is made up of a compressed sheet of felt saturated with tar or asphalt, to one surface of which a sheet of heavily napped fabric is cemented with the napped face out, while a sheet of woven fabric such as canvas is cemented to the other surface.

Dan. P. 24,696/19 Hjerpsted. Insulation is made of molten pitch mixed with iron oxides, hydroxides or carbonates.

U. S. P. 1,315,342/19 Sharpneck. A material suitable for paving roads, for sidewalks, reservoir linings, etc., is formed of earthy material such as soil or sand 80–85%, asphalt 12–7%, aluminum sulphate 2% and finely crushed limestone 6%.

U. S. P. 1,315,362/19 Cumfer. A roofing felt is corrugated and impregnated with a bituminous material which forms a coating on one or both sides.

U. S. P. 1,327,726/20 Murray. A paving material is formed by pulverizing earthy material, heating and mixing with it sufficient bituminous cement to coat the particles lightly, cooling, repulverizing, heating and mixing with more bituminous cement.

U. S. P. 1,328,310/20 Willis. Paving mixtures are formed of finely divided filling material such as sand or earth 80–90%, asphaltic binder 10–20% and 0.25–1.0% of copper sulphate. The latter serves to toughen and strengthen the mixture.

U. S. P. 1,330,139/20 Ruge. A pavement is formed of coal cinder rolled into a layer of sufficient thickness to withstand the load to be imposed upon the pavement and permeated with a bituminous binder.

U. S. P. 1,330,443/20 Glynn. A mixture of bitumen and soil is applied to felt for roofing purposes.

U. S. P. 1,343,680/20 Pine. A paving material is formed by coating fine stone or sand or other mineral particles with a layer of bituminous cement applied in the form of a frothy mixture containing a small proportion of water.

U. S. P. 1,347,869/20 Osborne. A composition comprising particles of asphalt, the particles being impregnated with air bubbles, set in a cellular structure of Portland cement.

B. P. 1,364,037/20 Clark. The process of treating fibrous material which consists in subjecting the same to a cooking or boiling operation, removing the material from the cooker or boiler and while in a hot and wet condition carrying the same through a bath composed of a hot binding and preservative agent with the material carried wholly away from the bottom of the bath, so as to convert the moisture in the material into steam and to impregnate the material with the binding and preservative agent, subjecting the vat to suction during the passage of the material through the bath so as to draw the steam vapors out of the vat, and finally compressing the material.

U. S. P. 1,364,622/21 Draney and Law. A non-precipitating plastic paving mixture composed of a bituminous substance and dust electrically precipitated from the floating discharges of plants for reducing calcareous and argillaceous materials.

Jap. P. 1,386,932/21. The method of manufacturing a paving material which consists in mixing tarry matter together with table salt (N_aCl), rosin saponified with slaked lime ($C_a(OH)_2$), and rosin which is sulphuretted with sulphur powder.

G. P. 1,391,710/21 Zimmer. A process of converting limestone into compressible artificial stone which consists in mixing powdered limestone with a bituminous substance in the presence of sulphated sebacic acid capable of emulsifying the bituminous substance.

U. S. P. 1,394,874/21 Wilson. A process of making a bituminous cement which consists in adding to a given quantity of bitumen heated to approximately 400° F. approximately 1% of borax and allowing the escape of the volatile oils.

F. P. 1,395,396/21 Carles de Caudemberg. A composition of matter for use as an industrial product, and resulting from the combination of bitumen with rubber

in a proportion of approximately 1-1.50 of rubber to 100 of bitumen, said composition having colloidal properties and a high point of fusion.

U. S. P. 1,404,060/22 Rich. A method of making cementitious products which consists in mixing Portland cement and finely divided clay to an amount equalling approximately one-third of the product to be obtained, adding an aggregate of earthy materials approximating two-thirds of the product to be obtained, and then thoroughly mixing the same with water in which saltpeter and sal ammoniac in substantially equal amounts have been dissolved and to which a quantity of creosote has been added, thereby making a homogeneous plastic composition which will set and harden to a solid mass impervious to the entrance of moisture.

SUNDRY PATENT REFERENCES

COMPOSITIONS OF VARIED CHARACTER

U. S. P. 933,982/09 Herbst. Composition for molds for casting artificial stone. Finely ground crystalline silica, with or without chalk 5%, made into paste with water.

U. S. P. 947,128/09 Robeson. Molded articles. Sand bonded by means of waste sulphite liquor, and coated with the latter.

B. P. 25,637/08 Winkler. Building material. Kneading finely divided fibrous substances capable of serving as substitute for wood, together with wet drying substances, drying the pasty mass obtained and mixing it with binding substances, with or without fillers, and molding under high pressure.

U. S. P. 948,727/10 Hart. Composition for knife handles. Ground rags and paper 75%, mixed with zinc chloride 25% in solution, and pressing out excess of liquid.

U. S. P. 955,431/10 Morimura and B. P. 27,266/09 Morimura. Chopped straw is boiled with lime water and salt, washed, soaked in tannic acid solution, dried, dipped in potassium dichromate solution, washed, dried, mixed with degreased hair, boiled in glue and alum solution, mixed with resin soap, and the mixture thus formed is molded to shape, dipped in formaldehyde solution, dried, soaked in a solution of gelatin and glycerol, allowed to drain, again soaked in formaldehyde, dried, dipped in solution of potassium dichromate and dried in the open air. Sodium silicate varnish and asbestos are applied in successive coats.

G. P. 220,943/09 Lemoine. Use of turkey red oil or its alkali salts in place of glycerol in the manufacture of plastic masses, especially for printers' rollers.

B. P. 21,670/09 Sinclair. Cement composed of coal tar 6 gal., asbestos fiber 1 qt., graphite 3 lbs., dry lamp black 8 oz., ground mica 3 lbs., Venetian red 4 oz., yellow ochre 4 oz., powdered alum 8 oz., red rosin 1 oz., sodium bicarbonate 1 oz., washing soda 1 oz., sodium thyosulphate ½ oz., common salt ½ oz.

F. P. 395,214/10 Wallace. Manufacturing elastic or plastic products by heating sugar in a bath of oil to a temperature above 200 deg. C.

G. P. 221,871/08 Schimmelpfeng. Light weight stone made from the ash of lignite, by moistening, forming, and drying, and then saturating it with a compound including lead oxide, gum, beeswax and gasoline.

F. P. 400,020/08 Geofrey. Process of agglomerating talc to manufacture crayons, plaques, blocks, etc., by making a paste of talc powder with sodium silicate, and, after desiccating, heating to 500–1000 deg. C.

B. P. 4,627/09 Frood. Material for brake blocks consisting of animal or vegetable fibrous material impregnated with enamel prepared from resin spirit 65, rock bitumen 25, copal 25, made soluble by linseed oil. The resulting product is hardened at a high temperature.

G. P. 224,098/09 Weber. Masses for molding are obtained from non-plastic substances without the addition of clay, by adding a small amount of alkali to the substance in finely divided form stirred up with a small quantity of water.

B. P. 2,903/10 Bost. A heat insulating compound composed of carbonized wood sawdust, wood turnings, shavings, planings, or the like, mixed with paper pulp, with or without waterproofer.

B. P. 11,926/10 Mendez. A composition for use as building material, paint,

etc., composed of sulphide of iron (e.g., pyrites), powdered and made into a semi-liquid mass with a suitable calcareous or argillaceous binder.

B. P. 27,394/10 Vallee. Composition for stopping of leaks, consisting of borax 5, sugar 4, dextrin 15, ground flaxseed 75.

B. P. 21,560/10 Mahler. In the manufacture of porous artificial stone, a mixture containing a gas developing substance is placed in molds. The formation of gas in the material causes it to press against the walls of the mold.

D. P. 14,619/10 Anderson. Caulking air conduits with a composition of pipe clay 2, sludge chalk 10, trip 1, water 20, and talc 1.

G. P. 235,077/09 Schweizer, also B. P. 11,942/11. Composition for imitation of the lead in leaded glass, consisting of potassium and sodium silicate, cement scourings, pulverized marble, pumice stone, or the like, graphite, and aluminum, tin, or zinc powder.

A. P. 2,737/10 Emele. In the manufacture of dry magnesia cement or of waterproof artificial stone, burned magnesite or burned dolomite with or without the addition of lime or burned gypsum is worked up together with alum or sulphate of alumina.

G. P. 247,671/10 Ehemann. In the manufacture of mortar from mineral waste and a binder, the mineral waste is mixed with oil or fatty substances before admixture with the binder.

G. P. 247,956/10 La Ballee. Rendering the metallic conduits for hot liquids impermeable by adding to the liquids a mixture of substances containing plant seeds, which contain drying oil, also an emulsifying alkali substance and a binder.

G. P. 248,912/11 Ehlers. Weather and acid proof building material, consisting of asphalt 550, magnesia 250, ground leather scrap 75, resin oil 75, water-glass 50, concentrated alum solution 20, fine washed ignited sand 2500.

G. P. 249,910/11 Weisflog. Cement for building up lithographic stones from fragments, consisting of sodium silicate, calcium carbonate, burned magnesia, and zinc dust.

U. S. P. 1,040,321/12 Henderson. Making molded articles of preserved comminuted wood.

G. P. 247,982/08 Lotterhos. In manufacturing corrugated plates from fibrous materials and hydraulic binder, the fibrous cement layer is mounted upon a pliable base, such as imitation parchment, whereupon the layer together with the base, is corrugated.

B. P. 25,084/09 Cooper. A non-heat-conducting composition composed of a mixture of clay 13 cwt., soot 1 cwt., 2 qrs. hemp waste, 2 cwt. 2 qrs. molasses 4 lbs., water sufficient to bring the weight of mixture to one ton.

G. P. 231,147/09 Walther. Plastic stuffing material which resists heat is made by exposing a mixture of asbestos, talc, graphite, composition metal, animal and mineral fats and oil to high temperatures, to ensure even distribution of the binding agent.

U. S. P. 957,351/10 Kortling. Building block of unpressed peat impregnated with water-glass.

U. S. P. 968,505/10 Zolnay. Making reproductions of models by molding a thin layer of plastic material including asbestos pulp, kaolin, whiting, flour paste, and linseed oil about the original, permitting the product to dry and saturating it with a compound including lead oxide, gum, beeswax and gasoline.

B. P. 19,808/10 Rippe. Manufacture of artificial stone by blowing air or gas into molten fusible rock. Instead of blowing in gas a substance may be added which produces gas.

B. P. 28,667/10 Ferra. A composition for use as heat insulating material consisting of cuprous or cupric sulphide, sulphur, kaolin quartz, sand or clay.

U. S. P. 1,004,934/11 Taylor. Plastic composition, consisting of clay, vulcanized oil and a nitrated oxidizable oil, e.g., linseed or castor oil.

C. P. 263,610/11 Fried. Process of utilizing rubbish, which contains much ash from brown coal or brown coal briquets, for manufacturing light building stones.

G. P. 250,964/11 Martiny. Slag wool, 80–90 parts by weight with fibrous material such as asbestos, turf, or the like, 20–25 parts, is made into a felted mass for heat insulation.

G. P. 253,211/11 Konit-Ges. In the manufacture of artificial stone, material such as ash in a finely divided state is worked up together with finely flocked mineral fiber by means of readily volatilized binding agents such as oil solution, to form a dough, which is forced into molds, the shaped product being then again pressed, again heated, and after further pressing quickly cooled.

Norw. P. 24,491/11 Elmenhorst. A coating material for wood, cement and metal is made by mixing calcium, potassium and magnesium carbonates with asbestos fibers, and 30–40% water-glass solution, containing 20–25% of a mixture of equal parts of potash and soda lyes, is added.

U. S. P. 1,020,781/12 Taylor. Coating and insulating composition, made of clay, cocoanut fiber, sulphur and vulcanized oil.

U. S. P. 1,029,800/12 Ellis. Self setting putty containing mineral oil 80, wood oil 20, and whiting 400 parts.

U. S. P. 1,033,553/12 Delvan. Packing for journal bearings, containing sponge, palm oil and glycerol.

U. S. P. 1,039,413/12 Klee. Making boards or sheets of asbestos and a binder.

B. P. 839/12 Schol. Slag is converted into porous bulky lumps by causing it to flow over wet sand or the like. The sand may be formed into a sloping bed or may be spread on a conveyor band and carried past the slag outlet. The lumps are used as an aggregate in the manufacture of artificial stone.

B. P. 1,390/12 Wheeler. Artificial wood slabs, etc., formed from asbestos mixed with a filling material which may consist of burned clay and a binder, preferably consisting of or containing sodium silicate, are placed, after molding, in a suitable press having heated chambers.

B. P. 4,949/12 Owen. A plastic composition for modeling and similar purposes consists of paraffin wax (having a setting point of 104°–112° F.) 100, and French chalk 25–125. Colors and perfumes may be added.

B. P. 17,482/12 Sborowitz. Artificial stone. Materials such as ashes, sand, or mineral fibrous substances are mixed with a binder dissolved in a volatile solvent, such as copal oil in alcohol, benzine or benzol, and are pressed in a mold. Then heated; pressed and heated again.

B. P. 17,648/12 Krupp Akt.-Ges. In the manufacture of plastic metallic packing, thin metal flakes or leaflets obtained by directing a current of compressed air or steam against a thin stream of molten metal, are mixed with flaky graphite, asbestos wool, and neutral fat of high melting point.

B. P. 18,883/12 Laufer. In the manufacture of artificial stone there is used: coarse porphyry (or the like) 40, fine porphyry such as porphyry tuff 50, aluminum phosphate 6 parts, and sodium carbonate 4. The mixture is moistened, pressed into blocks, and heated. Silica and lime may be added in quantities of 5–10% to regulate the clinkering. To increase the cementing power of the mass, colloidal alumina may be added in the proportion of 2–8% aluminum hydroxide.

B. P. 27,851/12 Cuthbertson. In making conducting coverings for heat, asbestos fiber, etc., is sifted over a flat surface, and glue, etc., is sprayed over it, the operations being repeated until the layers are of the thickness required, and the material may then be rolled. Asbestos string or the like may be incorporated with the layers to reinforce them.

G. P. 258,681/12 Von Zakrzewski. In the manufacture of a permanently fit

hygroscopic plastic mass for modeling, etc., slimed and pulverized clay is worked up with an emulsion of glycerol, animal and vegetable fats, saturated salt liquor, dextrin, or gum, and a very small amount of potash lye, to a thick sludge.

G. P. 260,806/12 Fochtenberger. Manufacture of hard packing material from animal and vegetable waste and sand.

G. P. 268,881/12 Von Jaraczewski. In the manufacture of a filtering material from fibrous matter and coal, a finely fibrous substance (such as fustian) is treated with water, alcohol and bone-black. After drying it is placed on a sieve and there is poured through it a mixture of bone-black, fibrous asbestos, and cellulose suspended in water. After drying the product is pressed and rolled.

G. P. 269,380/12 Busch. In making glazier's putty from oil, chalk, and varnish, wood or straw is added in meal form to these materials. This putty is lighter and cheaper, does not shrink or peel, and remains unchanged in cold or heat. Sawdust 1 volume is mixed with dry slimed chalk 6, and linseed oil varnish is added until desired consistence is obtained.

G. P. 274,525/12 Mombaur. Artificial stone products are made from refuse after the separation of the combustible constituents and sorting into fine and coarse material. The fine refuse is caked with marsh slime, water-glass, and manganese dioxide, and is dried and ground; it is then mixed with the ground coarse material, pressed with binders such as a mixture of stearin pitch, sulphuric and inorganic additions, and dried.

U. S. P. 1,056,316/13 Bushman. Plaster board made from sand 16, Portland cement 24, woody fiber 96, water 50, sodium silicate 100 and nitric acid 4 parts.

U. S. P. 1,071,044/13 Gilson. Making a composition for bearings, dynamo brushes, etc., by heating a mixture of graphite with oxides of tin and copper to 600–700 deg. C. until all but one-half to five per cent. of the oxides are reduced to metal, then compressing the mixture into its desired shape and continuing the heating to complete the reduction of the oxides.

U. S. P. 1,074,983/13 Sborowitz. Artificial stone made from ashes, coloring matter and a binder dissolved in a volatile solvent, such as benzene.

U. S. P. 1,077,131/13 English. Mixture for smoothing floors, formed of boric acid 100, corn starch 10, soapstone 10, and soda ash 5 parts.

U. S. P. 1,077,252/13 Bache. Coloring wood by treatment with a boiling bath of paraffin 100, carnauba wax 20, rosin 20 and coloring matter 3.5 parts.

U. S. P. 1,078,307/13 Parkinson. Making an insulation for steam pipes, etc., by treating mineral wool with the smoke from burning petroleum, mixing with flax fiber and paper pulp and shaping the mixture.

U. S. P. 1,083,142/13 Rommel. Artificial building stone formed by mixing hot sand 2500, magnesia 250, concentrated alum solution 20, ground leather 75, water glass 50, asphalt 550, and resin oil 75 parts.

U. S. P. 1,085,652/14 Whitaker. Mixture for filling cavities in trees, made from sawdust mixed with paraffin 3, pitch 9 and pulverized slate 2 parts.

B. P. 2,894/13 Magelssen. Slates or tiles made of a composition of asbestos and water-glass are bedded on a continuous layer of the same composition, which is applied to the roof of the wall.

B. P. 3,720/13 Weiler. In the manufacture of artificial stone from peat for heat-insulation, etc., there is taken 60 parts peat, dried and cleaned, 4 of cement powdered, 4 of soluble glass powdered, 4 of magnesia, 6 of kieselguhr, 16 of glue, and 6 of lime-water. It is molded under pressure.

B. P. 7,002/13 Hidoux. Artificial stone or brick is made from the incombustible matter obtained from house refuse or slag from incineration ovens, or both, and green calcareous or other clay.

B. P. 11,182/13 Tussaud. A composition for making models consists of modeling-clay, such as terra-cotta, to which is added dextrin, gum, or starch (1.3 parts

dextrin to 10–20 parts clay). It may be colored, and the model, which does not require firing, may have its surface waterproofed or painted.

B. P. 14,058/13 Schon. About 80 parts of magnesite are mixed with 10 parts each of silk and asbestos fiber or glass-wool, and 1.5 parts of glue soaked in water, for use as a heat-insulating coating for boilers, pipes, etc. After applying the coating, it is treated with formalin. The silk and asbestos may be impregnated with ammonium carbonate, and resin or rubber may be added.

B. P. 14,063/13 Halle. A plastic composition for coating roofing-felt, etc., consists of stearin pitch, or the asphaltic residues of petroleum, tar or fat, a mineral color, such as lithopone, oxide of iron or ocher, and montan wax or residue from the manufacture of montan wax.

B. P. 81,802/13 Sucich. Packing for stuffing boxes is made from a mixture of granules of bearing-metal, 100 parts by weight, unwashed whiting 20, graphite flakes 5, 1–2 pine or like soot, and 5 parts of acid-free rape-seed, linseed, or other oil or fat.

U. S. P. 1,092,320/14 Winding. Waterproof and fire-resistant building material is formed by impregnating a porous mass of asbestos with coal tar and burning the latter in the asbestos so as to partly graphitize the carbon produced.

U. S. P. 1,103,441/14 Sewell. Plastic packing for piston rods, etc., formed of pulverized alloy of tin 15, antimony 17 and lead 68 parts or other anti-friction metal 54, flake graphite 18, cylinder oil 18, asbestos cement 6 and asbestos fiber 4 parts.

U. S. P. 1,119,004/14 Drewsen. Apparatus for making a bisulphite liquor mixture of lime 2%, starch sizing 2%, asbestos fiber 48% and mineral wool 48%.

U. S. P. 1,122,883/14 Edmiston. Elastic cement for filling cracks of buildings, etc., is formed of gilsonite 8%, rosin 2%, graphite 8%, pine creosote oil 15%, petroleum residuum 42% and asbestos 25%.

B. P. 8,820/14 Fox-Bourne. Homogeneous articles such as bottle-stoppers and buttons are made from a mixture of a body material, such as powdered asbestos or hard wood, and of a binder such as pitch or shellac, by disintegrating the body and binder, mixing, compressing into a solid block, heating until the binder becomes viscous or liquid, cooling, disintegrating the block and again mixing, and compressing the re-mixed materials into solid form.

G. P. 293,221/14 Oettershagen. For heat-insulating products flue dust from the blast furnace is treated to remove uncombined iron; aluminum compounds and combustible substances are added, the mass is shaped, dried and burned. The dust and scrap resulting are worked into plastic masses with clay and binders.

U. S. P. 1,133,380/15 Keener. A composition for making packing boxes or insulating material is formed of sodium silicate solution 16, finely divided cotton 1, iron oxide 4 and completely oxidized mineral ash 144 parts or more.

U. S. P. 1,135,176/15 Gossett. Artificial building stone is formed of rock salt 16, iron oxide 6, volcanic ash 10, sand 20, ground asbestos 4, powdered rock 10, and ferrous sulphate 1 part.

U. S. P. 1,151,690/15 Kelley. A friction fabric for brake-linings, etc., is made of woven asbestos impregnated with a mixture of alum, magnesium sulphate and a decoction of ground bone.

U. S. P. 1,160,701/15 Erwin. A composition for filling cavities in trees is formed of ground asbestos 40, refined coal tar 50, pine oil 8 and a pigment (such as to match the bark of the tree to be filled) 2%.

U. S. P. 1,161,289/15 Christie. As heat-insulation for steam pipes, etc., flax straw 1 and fire-clay 16 parts are mixed with water and with a binder formed of water impregnated with iron rust, vinegar, borax, glue and linseed oil.

U. S. P. 1,162,371/15 Kelley. A brake-lining fabric of asbestos is impregnated

with a solution formed by dissolving magnesium sulphate and alum in a hot decoction of ground bone and beer vinegar.

B. P. 2,708/15 Kahn. A substitute for asphalt for floors, walls, ets., consists of 50% sand, powdered stones, etc., 40% paraffin, bees-wax, or ozokerite, 10% carnauba wax, and vegetable black for coloring.

B. P. 15,248/15 Harkko. Putty is made by boiling rosin oil 700 parts till it ceases to froth and then stirring in 300 parts of petroleum, chalk is added to this mixture.

B. P. 15,249/15 Harkko. Putty is made by adding chalk or whitening to a mixture of glue, petroleum, and bolted meal, each 50 parts, rosin oil 350 parts, and water 500 parts.

U. S. P. 1,178,546/16 Snyder. In coating molded carbon articles, they are first dipped into a bath of sulphuric acid or caustic soda to open up their pores and are then coated.

Aus. P. 71,253/16 Kulka. In making artificial stone from porphyry or like volcanic rock by sintering without the employment of a flux, the initial material is ground, the fine and coarse screenings are mixed in such proportions that spaces are not left upon compression, the mass is moistened with about 8% water, compressed to the desired shapes at about 200 atmospheres and burned at 1100°–1300° C.

Jap. P. 30,387/16 Kwagaku Kigyo Co. A substitute for earthenware is made of whetstone powder, fiber, soap, flowers of sulphur, pitch, naphthalene, shellac and tar benzene, mixed in the hot state and subjected to cold rolling. The resulting solid plate, after being softened by heat is suddenly compressed between cold matrices under high pressure.

S. P. 40,358/16 Kristensen. A composition for stereotype plates consists of a mixture of metal powder and water-glass.

U. S. P. 1,223,846/17 Bachman. A composition for surfaces of blackboards is made of a mixture of sulphur 16, bees-wax 1, rosin 4, pitch 4, asphalt 2, finely divided carborundum 40, powdered slate 16, crystolon 40 and shellac 25 parts.

U. S. P. 1,264,307/18 Kohncke. A plastic roofing composition that is waterproof and fireproof is formed of magnesia 30, crushed quartz 8, white talc 4, marble 4, carborundum fire sand 4, long fibered asbestos 4 and sawdust oiled with about 5% of China wood oil 2 parts.

U. S. P. 1,276,221/18 Hudson. A plastic compound which will adhere to wood, metals, stone or glass is formed of burned sand 9 lbs., powdered stone 90 lbs. and litharge 1 lb., mixed with about 1.8 gals. of a liquid formed of Chinese wood oil 50, kerosene 35 and benzine 15%. It is used as stucco or cement.

Swiss P. 77,382/18 Wallin. A hard plastic flooring is made of sawdust, asbestos or the like mixed dry with magnesium nitrate or substances which react to yield this salt. The mixture is worked into a cement with water.

U. S. P. 1,297,583/19 Mock. A heat-insulating material adapted for use in refrigerators, fireless cookers, etc., is formed of cellular sulphur which may be prepared by mixing powdered sulphur with common salt, melting, allowing to solidify, and then dissolving out the salt. Gums, resins, or magnesium carbonate or other modifiers may be added.

U. S. P. 1,319,286/19 Johnson. A flooring mixture is formed of sawdust 1, dry earth 1, mineral color 1, plaster of Paris 0.2 and "Sipe's Japan oil" and "Seaware oil" mixed together 0.83 part.

U. S. P. 1,349,156/20 Jarvis. A composition containing acetyl cellulose compound, in combination with acetone cinchonine and its salts.

U. S. P. 1,351,087/20 Sutter. The process of forming structural material from infusorial earth or kieselguhr, which consists in saturating said material with a hot soap solution, then adding to such material a cold solution of a salt of a metal which will react with said soap to precipitate an insoluble soap of said metal,

washing out from the resultant product the soluble hydroxid or salt produced by the reaction, and, while the material is still wet, mixing therewith a water setting binder.

Argentine P. 1,351,617/20 Butty and Alvo. A composition for forming articles in imitation of china, consisting of sulphur 40%, clay and cement 60%, and a coloring matter.

U. S. P. 1,353,003/20 White. A bituminous pitch and sulphur composition of coal tar pitch and sulphur in which the major portion of the ingredients are not chemically combined.

B. P. 1,353,384/20 Dreyfus. A composition of matter containing cellulose acetate, and containing a high-boiling mixture of isomeric xylene monomethyl sulphonamids which mixture is liquid at ordinary temperature.

B. P. 1,355,689/20 Quin and Lacey. A refractory composition comprising mica, asbestos and salt ground and mixed substantially in the proportions of 6 parts by weight of mica, 6 parts by weight of asbestos, and 2 parts by weight of common salt.

Austrian P. 1,355,985/20 Lilienfeld. A process for directly preparing viscose which consists in producing an alkali cellulose by treating 100 parts of cellulose which has not previously been hydrolyzed with an amount of caustic alkali equivalent to about 25.2 parts of NaOH per 100 parts by weight of cellulose, and thereafter subjecting such alkali cellulose to the action of carbon bisulfid.

U. S. P. 1,357,335/20 Miles. Cellulose ester composition consisting of cellulose acetate, a volatile solvent thereof, and the aggregate of fatty acids extractable from cocoanut oil.

U. S. P. 1,357,594/20 Schmidt. A marking composition comprising 1 lb. of an iron salt, 1 oz. starch, 1 oz. glue, ½ oz. glucose, and ½ lb. plaster of Paris.

U. S. P. 1,357,614/20 Clarke. The process of making a composition of matter which consists in combining a cellulose ether and a dibutyl sulphone by the use of a solvent containing chloroform and alcohol.

U. S. P. 1,357,852/20 Dodge. A liquefiable composition for the waterproof sealing of wrapped articles comprising 17.5% of pitch, 52.5% of paraffin wax, 10.0% of carnauba wax and 20.0% of rosin.

U. S. P. 1,357,876/20 Kessler. A composition consisting essentially of nitrocellulose and alkyl ester of an acyloxy derivative of a monobasic aliphatic acid having more than three carbon atoms.

U. S. P. 1,359,137/20 Wile. A cement for filling voids in brass castings consisting of brass grindings or other finely divided brass mixed with an aluminum derivative, zinc oxid and phosphoric acid.

U. S. P. 1,360,759/20 Kessler. A composition consisting essentially of cellulose nitrate and a softener comprising camphor and acetin substantially free from monoacetin, said acetin containing about 40-30% of diacetin, and about 60-70% of triacetin, the ratio of said cellulose nitrate to said softener being about 3:1.

U. S. P. 1,363,563/20 Calta. A composition of matter for sealing piston rings, which consists of a refractory lubricating paste, comprising a mixture of soapstone, mica, asbestos fiber, flake graphite, fine plumbago and mineral oil in the following proportions to wit: 30% soapstone, 30% mica, 20% asbestos fiber, 10% flake graphite, 10% fine plumbago, and mineral oil sufficient to make the paste.

U. S. P. 1,365,891/21 Carter. The process which consists in the mixing of fibrous material and water in a paper beater, adding an alkaline solution of an organic filling material and an alkaline solution of cellulose xanthate, freeing the gum or oil by the use of sodium bisulfite, in quantity insufficient to regenerate the xanthate, collecting the mass, drying it and then regenerating the xanthate by the application of heat and pressure.

U. S. P. 1,368,945/21 Lake. A plastic composition used as a power transmitting member for a fluid clutch, said composition consisting of graphite as a base with glycerin and a fibrous material added thereto to form a plastic fluid mass of such a

consistency that when compacted, it will have sufficient solidity to resist the movement of one member of a clutch in respect to another and when not compacted will allow one member to move free of the other.

U. S. P. 1,370,647/21 Henderson. A process of treating fibrous vegetable material, forming comminuted fibrous particles of substantially uniform thickness, of irregular lengths and breadths, removing sap, soft, pulpy portions and all matter soluble in water, from the particles, and impregnating the particles with a preserving compound of a binding nature, and compressing the same into shape.

U. S. P. 1,370,853/21 Stockelbach. A composition comprising a cellulose nitrate, a phosphoric ester of one of the homologous series of aromatic alcohols of which benzyl-alcohol is a member, and camphor.

U. S. P. 1,370,878/21 Clarke. A process of making a composition of matter which consists in combining cellulose nitrate and a dibutyl sulphone by the use of a solvent containing acetone and methyl alcohol.

U. S. P. 1,370,879/21 Clarke. A process of making a flowable film-forming composition of matter which consists in combining cellulose acetate and a sulphone in a solvent common to both.

U. S. P. 1,373,044/21 Baker and Weaver. A process of making a fusible odorless resinous composition which consists in oxidizing the odor producing ingredients in the resin and avoiding the formation of odor producing compound by fusing the resin and limiting its temperature to substantially the point of fusion at which odor producing compounds are not formed, and adding an oxidizing agent capable of giving off nascent oxygen in quantity sufficient to destroy the odor producing ingredients originally in the resin and insufficient to affect the properties of its major constituents.

U. S. P. 1,374,136/21 Beecher. A safety tread tile comprising a body of non-argillaceous glass having intimately distributed throughout its volume a quantity of granules which have a hardness of nine or more and are adapted to be exposed on the surface of the tile, as the latter wears away, and prevents a pedestrian slipping thereon.

U. S. P. 1,374,909/21 Louis de Bats. The method of making crucibles or pots containing clay, which consists in mixing copper-containing metal with the material from which the crucible or pot is formed, and forming the crucible or pot therefrom, whereby in the use of the crucible or pot the metal forms a metallic silicate coating on the surface thereof.

U. S. P. 1,374,910/21 Louis de Bats. A material suitable for making crucibles or pots comprising clay and graphite and having incorporated therein metal of the aluminum-magnesium group in a finely divided form.

U. S. P. 1,376,172/21 Snelling. A process of producing a soft plastic vulcanized oil product that comprises mixing about 34 parts of cottonseed oil, about 23 parts of carbon bisulfid and about 26 parts of ethyl alcohol, agitating the mixture to produce an intimate emulsion, adding about 17 parts of sulphur chlorid, stirring until the mixture tends to boil, pouring the mixture in a thin film on a cold surface, curing the said film by allowing it to remain for some time in a closed vessel in contact with the gases produced in the vulcanizing reaction, boiling the cured film in water, and mechanically working the resulting mass.

U. S. P. 1,377,960/21 Dodge. A tile comprising wear-resisting, antislipping granular material of a hardness of nine or more and a proportionately small amount of a vitrified, glassy ceramic bond unitarily united as a dense porous structure of high tensile strength, which has an imperforated and continuous tread portion consisting mainly of said granular material and being capable of resisting wear and preventing slipping of foot gear thereon.

Austrian P. 1,379,351/21 Lilienfeld. A process of making cellulose xanthogenate solution from viscose which comprises heating to a temperature of from 60°-80° C.,

without addition of other materials thereto, a viscose solution obtained from an alkali cellulose containing an amount of caustic alkali equivalent to not more than 30 parts by weight of caustic soda to 100 parts of cellulose, thereby obtaining a precipitated cellulose xanthogenate which is insoluble in water, washing said cellulose xanthogenate thoroughly with water, and dissolving the same in a solution of caustic alkali.

U. S. P. 1,379,596/21 Seel. As an article of manufacture a flowed, strong, flexible, transparent, waterproof, sheet of reduced inflammability, comprising cellulose nitrate, a monohydroxy, aliphatic alcohol containing 4-5 carbon atoms and triphenyl phosphate.

U. S. P. 1,380,258/21 Seel, Combs, and Kemp. As an article of manufacture, a flowed sheet consisting only of nitrocellulose and aliphatic alcohols containing 4-5 carbon atoms.

U. S. P. 1,380,922/21 Nicholas. A composition for filling cavities in trees consisting of a mixture of approximately 33-1/3% of calcined magnesite, approximately 66-2/3% of finely divided wood and magnesium chlorid in quantities sufficient to produce a plastic mass.

U. S. P. 1,381,118/21 Gerlach. A method of making an insulating composition including mixing infusorial earth with water to form a thick paste, adding dilute sulphite liquor, then stirring a solution of ammonium carbonate thereinto and finally adding and stirring into the mixture acetic acid diluted with water.

U. S. P. 1,381,738/21 Priest. A linoleum composition which comprises mixing together an oil and a polymerized product of the coumarone or indene group of compounds at a temperature not above 100° C. and grinding them together between rolls.

U. S. P. 1,382,329/21 Stowell. A composition to be mixed with Portland cement in the formation of fireproof and insulating structures, consisting of wood particles, and sodium silicate constituting means for filling the pores of the wood particles and for binding the particles together, the sodium silicate having a filler of powdered pumice forming a light body therefor.

U. S. P. 1,382,986/21 Kregelius. A method of making a waterproofing compound, which consists in melting paraffin-wax, admixing finely ground unslaked lime therewith in the proportion of approximately 2-1 parts by weight, allowing the mixture to cool, and then exposing the resultant cake to the action of the atmosphere, whereby such lime is slaked and a fine powder formed of such wax in intimate association with particles of slaked lime.

U. S. P. 1,383,692/21 Benford. A pulley-face frictioning composition comprising a hard-drying liquid substance consisting of ground glass free of other solid material; and water-glass mixed therewith to form the composition; said ground glass, when the composition is dry on the pulley-face, forming sharp granular means adapted for extracting oil particles from a belt.

U. S. P. 1,383,864/21 Scobel. A solid formed at ordinary temperature and susceptible to further toughening by exposure to moderately heated air and consisting of a composition of China wood oil as an active metallic halogen derivative.

U. S. P. 1,384,375/21 Ander and McGuire. The process for manufacturing tailors' chalk, consisting in mixing a plastic clay substance with a coloring matter, forming the mixture into cakes, drying the latter under a mild heat, submerging the dried cakes in a liquid oleaginous substance to become saturated therewith, and finally drying the same.

U. S. P. 1,385,808/21 Abraham. A waterproof shoe bottom filler, composed of bituminated non-felted fibers, which when heated within a range of from 200°-400° F. will assume a plastic consistency, enabling it to be readily troweled into the cavity between the sole and insole of a shoe, and which at atmospheric temperatures will regain a tough, resilient and pliable state.

U. S. P. 1,386,576/21 Lindsay. The process of making a composition of matter which consists in combining an acetyl cellulose, tricresylphosphate and urea by the use of dichlorhydrin and a solvent of said acetyl cellulose and tricresylphosphate.

B. P. 1,386,620/21 Hotson-Tait. A preparation for sealing tins and the like consisting of a mixture of resin, methylated spirit, carbonate of iron, flour paste, molasses, and nitric acid.

F. P. 1,386,995/21 Dorel. A method of manufacturing a white gelatinous composition for use in the production of line documents, consisting in first melting gelatin in water; second adding hereto while stirring a hot solution of sodium sulphate in water; third, adding in a similar manner a hot solution of barium chlorid in water; lastly, adding in a similar manner a hot solution of ferrous sulphate in water.

U. S. P. 1,390,038/21 Jones and Westlake. A process of forming bricks, tile and the like which consists in solidifying a dry material consisting of silica, lime, magnesia and sulphur within molds and under intense pressure to cause cementation thereof.

U. S. P. 1,390,995/21 Kitsee. A process of dissolving a mass of cellulose, comprising fibers over-lying each other, which consists in subjecting said mass to a rubbing action in the presence of solvents whereby the lowermost fibers are dissolved and adjacent fibers are exposed and subjected to said rubbing action.

Sweden P. 1,392,127/21 Eklund and Löfveberg. An insulating and building material consisting of a mixture of marl and cellulosic fiber.

U. S. P. 1,393,225/21 Krieger and Jordan. The process of making heat insulating bodies which comprises molding and drying the waste diatomaceous earth derived from sugar refining, and burning the molded articles to increase the mechanical strength thereof.

U. S. P. 1,393,346/21 Cook. A composition of matter comprising substantially 10 parts of pulverized soapstone, 1 part of feldspar, 1 part of flint, ½ part of ball clay, and a binder consisting of sodium silicate.

G. P. 1,394,241/21 Weber. Method for producing pastes that may be poured into molds from clay- or kaolin-bearing mixtures and unplastic materials, which by the mere addition of alkali are only liquefied with difficulty, by the addition of small quantities of vegetable extracts of non-acid character.

U. S. P. 1,394,414/21 Hogan. A waist line belt made from a composition comprising 100 cubic units of rubber, 100-135 cubic units of powdered cork, and 4-8 cubic units of rosin.

U. S. P. 1,394,500/21 King. The process of making abrading tools, comprising mixing abrasive grain with a bond of rubber, sulphur and a vulcanization accelerator, shaping the mass by compacting it in a mold under high pressure for a short time at ordinary temperatures, confining the shaped mass to prevent deformation and thereafter completely vulcanizing the bond in one heat treatment in the absence of high external pressure.

U. S. P. 1,394,752/21 Miles. The method of producing a cellulose acetate uniformly impregnated with a small percentage of glycerin, which consists in first heating cellulose acetate in admixture with an abundance of glycerin, then eliminating the glycerin by washing with water, then mixing the washed cellulose acetate with a glycerin-water mixture, and finally eliminating the water, as by evaporation.

G. P. 1,395,729/21 Plauson. The process of preparing a colloidal dispersion of a protein in a suitable organic dispersion medium and then using this dispersion as binder to consolidate the dry protein.

G. P. 1,395,834/21 Kohner. A process to obtain horny bodies from powdered albuminous substances which comprises agitating the powdered albuminous mass, introducing a jet of vapor including water and ammonia, and whirling a portion of

the powdered mass above the main body of the substance until a determined content of moisture is evenly distributed in the mass.

B. P. 1,395,990/21 Crawford. A method of manufacturing bricks and the like, which comprises burning a suitable gangue in an oxidizing atmosphere at a temperature of approximately 1500° C., then mixing the burned material with a relatively small quantity of dehydrated cement, then moistening the burned mixture enough to cause the same to ball or stick together, then pressing the mixture into form, then immersing said form in cold water until the air bubbles are removed, and finally air drying the pressed bricks at a low temperature.

U. S. P. 1,397,528/21 Kutner. A method of producing material for cores of printers' rollers which consists in mixing substantially 800 parts by weight of a vegetable oil, 15 parts by weight of calcium oxide, 12 parts by weight of mineral oil, and 100 parts by weight of sulphur chlorid, agitating the mixture and allowing the same to cool, the agitation permitting the escape from the mixture of the occluded gases, and resulting in a viscous liquid; then adding to 100 parts by weight of the result of the first step 10 parts by weight of sulphur chlorid gradually adding the sulphur chlorid and agitating the mixture as the sulphur chlorid is added, then while the mixture is still heated pouring the mixture into a suitable mold for the production of the product desired.

U. S. P. 1,398,939/21 Clarke. As an article of manufacture, a sheet of deposited or flowed cellulose nitrate containing phenyl phthalate and a monohydroxy aliphatic alcohol having 4-5 carbon atoms and boiling above 100° C.

U. S. P. 1,398,949/21 Sulzer. A composition of matter comprising acetone-soluble cellulose acetate, an amount of ethyl butyrate not exceeding 40% of the weight of said acetate and sufficient acetone to render the composition flowable.

U. S. P. 1,399,336/21 Cole. A composition of matter for interior decorative finish, consisting of wood pulp to which is added wheat flour for an adhesive, petrolatum to prevent excessive hardening, and glycerin as a non-drier, and adapted to be applied to interior decorative surfaces by use of adhesives, and to receive a surface finish after being applied.

U. S. P. 1,400,196/21 Willkie. A process which comprises forming a film by evaporating a solution of cellulose ester in a solvent consisting of an ester having a dehydrating action and an alcohol adapted to form a constant boiling mixture with and carry off water during the evaporation of the solvent.

U. S. P. 1,403,327/22 Jones. A coating and sealing compound consisting only of Portland cement, linseed oil, Japan drier and coloring matter.

U. S. P. 1,405,449/22 Seel. A viscous flowable film-forming composition, comprising an alkyl ether of cellulose dissolved in a mixed solvent containing 90-10 parts by weight of benzol and 10-90 parts by weight of methyl acetate.

U. S. P. 1,405,490/22 Clarke. A composition of matter comprising 100 parts of ethyl cellulose, 300-800 parts of a solvent containing benzol and ethyl alcohol and 1-100 parts of a benzoic acid ester of a monohydroxy aliphatic alcohol having 4-5 carbon atoms.

U. S. P. 1,405,491/22 Clarke. A composition of matter comprising 100 parts of ethyl cellulose, 300-800 parts of a compound benzol and ethyl alcohol solvent and 1-50 parts of phenyl phthalate. As an article of manufacture, a sheet of deposited or flowed cellulose ether containing phenyl phthalate.

U. S. P. 1,407,608/22 Wawrzyniak. A conglomerate building material, comprising 1 part cement, 4 parts wood fiber, 2 parts fibered "Acme," liquid to reduce to a mortar and a plurality of weed stalks as a reinforcement.

Sweden P. 1,407,696/22 Luft. The improvement in the manufacture of artificial goods from viscose consisting in the addition to the viscose of any of the salts of the acids of naphthenes which are soluble in water as and for the purpose specified.

U. S. P. 1,408,095/22 Kessler. A composition containing 7 parts of a softener

comprising an alkyl ester of acetyl-salicylic acid and about 20-24 parts of cellulose nitrate.

U. S. P. 1,408,760/22 Mitchell. A process for producing a fireproof composition which consists in mixing steel wool fiber with a mass of disintegrated fibrous absorbent material, saturating the mixture with soluble silicate under pressure in a mold, and then immersing the saturated mass after having been withdrawn from the mold in a solution of calcium chlorid, to set up dialysis and cause cementation of the mass by crystalline deposition within the same by the reaction of the calcium chloride upon the soluble silicate.

U. S. P. 1,409,237/22 Pullar. A product comprising in substantially equal parts vegetable pitch and oxidized residuum oil, said product having a melting point between 160° and 230° F.

U. S. P. 1,411,708/22 Carroll. A viscous flowable film-forming composition, comprising water-insoluble ethyl cellulose dissolved in a compound solvent containing monochlorbenzol and a liquid monohydroxy aliphatic alcohol.

U. S. P. 1,411,912/22 Fisher. A liquid friction dressing composition comprising melted vulcanized rubber having a solid, powdered friction material incorporated therewith.

U. S. P. 1,413,002/22 Bummara and Ragonesi. An imitation bark of tree composition consisting of 16 oz. shredded paper, 8 oz. glue, 1 oz. blue colored powdered earth, 2 oz. burnt umber, 1 oz. green colored clay, and 1 oz. yellow colored powdered earth.

U. S. P. 1,413,557/22 Phillips. As new articles of manufacture, rubber compositions and products having phenanthrene incorporated therein prior to the vulcanization thereof.

U. S. P. 1,414,570/22 Hurley. A crayon consisting of animal fat, paraffin, turpentine, and pigment.

U. S. P. 1,415,059/22 Seel. A flowable film-forming composition of matter comprising nitrocellulose, a volatile common solvent, an amount of a sugar equal to approximately 4% or less of the weight of the nitrocellulose, an amount of glycerin equal to substantially 4% or less of the weight of the nitrocellulose and an amount of water equal to substantially 4% or less of the weight of the nitrocellulose.

U. S. P. 1,415,850/22 Erdahl. As a new composition of matter, a cellular or pervious material rendered waterproof and weatherproof, alkali-water resistant, indurated and of increased strength with a cohesive, impermeable filling or film resulting from treatment with a fortified metal-alginate-gel prepared by reacting in the cold a chemically pure metal-alginate with ammonia, and thereafter adding an ammonia emulsion of wax, the ammonia evaporating on gradual drying and heating to a temperature of approximately 140° F., whereby the ammonia soaps are decomposed without the production of soluble salts in the film.

U. S. P. 1,417,837/22 Kirschbraun. A process of oxidizing bitumen consisting in mixing bitumen, particles of which are in a discrete form in an aqueous vehicle with an oxidizing agent.

U. S. P. 1,417,838/22 Kirschbraun. A prepared bituminous product, consisting essentially of a solid body, being the residue remaining from the distillation with an inert gas of wax tailings, said body being yellowish brown pitch, having a conchoidal fracture when cold and being free from any substantial products of decomposition and a coloring matter intimately mixed with said solid residual product and giving a distinctive color thereto.

PULP AND FIBER COMPOSITIONS

G. P. 266,278/12 Bermig. In making tubes or the like from fibrous material and hydraulic binding agent, the fibrous material is first ground up to a slurry, with

the addition of the hydraulic binder and water. The slurry is much diluted with water and made up into a sheet on a pulp or paper machine, and this sheet is wrapped up, on a roll, into a tube.

G. P. 270,305/12 Schlisske. In making building material, cut unpressed turf pieces, after drying, are provided with a stiff crust by saturating in vacuo with a mass which is to render them either waterproof, or to a certain degree fireproof.

Dan. P. 17,888/12 Steenstrup. A hard product is made when turf is digested in a closed container with 20% alkali (sodium hydroxide), the mass washed out, and the resulting sodium cellulose is decomposed with an acid or a salt, and washed out. Preferably, the humus material is removed by means of ammonia, the resulting ammonium compound is a good fertilizer. The solid product may be colored and rendered waterproof by an impregnating agent. It may be formed into blocks and plates, and worked like wood after drying.

U. S. P. 1,097,666/14 Peterson. Composition for making water closet seats, etc., formed of pulped old newspapers and wood fiber molded and hardened with a binder of rosin 45%, ''kidney oil'' 45% and paraffin 10%. The ''kidney oil'' is a distilled oil from rosin, containing a small amount of water.

F. P. 457,875/13 Donnermann. For a heat-insulating agent, waste paper is macerated in soda solution of 6 deg. Beaume at 50–60 deg. C. and the pulp is used as a covering.

U. S. P. 1,111,021/14 Hoss. Fireproof wall board is formed of sawdust 46, sodium silicate 26, soapstone 22 and water 6 parts. After molding, the material is treated with a 25% zinc chloride solution.

Holl. 3,938/14 Beindorff. In making a heat insulating material, 20–60% of wood paper or pulp are ground together with 1.5–6% resin, in a ball or like mill. In a mixing machine 10–30% kieselguhr, 10–30% alum, 10–25% chalk, and 5–20% sawdust are mixed, and the first mixture with simultaneous spraying with water, is added.

U. S. 146,787/15 Dolley. A plastic composition for use in making molded receptacles, etc., is formed by adding water to mixture of powdered kaolin 200, wood pulp 100, casein 5, gelatin 5 and sodium resinate 10 parts, to form an emulsion, and then spraying into the latter a solution of gutta-percha or balata 5 parts dissolved in benzol. The product is resistant to both alkalies and acids.

U. S. 1,153,512/15 Muench. Heat insulating material is formed of felted wood-pulp tailings, made into sheet form, fire-proofed, pressed and dried.

U. S. 1,153,970/15 Sutherland. Imitation wood is made of compressed fiber impregnated with boric acid and red gum (from Eucalyptus rostrata). The fiber may be obtained from straw, paper, wood pulp, etc.

U. S. 1,169,079/16 Lappen. Heat insulating material is made when degummed flax fiber and shives, mixed with short-fibered straw, beaten to a consistency of ''halfstock'' with water 500, is mixed with melted petroleum tailings 40, crude paraffin 20, mineral wool 500, and alum 7 parts, and the mixture is molded into sheets or boards.

B. P. 21,437/14 Beindorff. A heat insulating composition consists of 20–60% of wood pulp or like fibrous organic pulp, 1–7% of resin, and 15–50% of a mixture of kieselguhr, and sawdust with or without alum and fillers, such as chalk. It is molded without pressure.

U. S. P. 1,184,518/16 Clapp. Waterproof stiff fiber-board is made of manilla paper beaten up and mixed with a solution formed by digesting leather with soda lye; rosin size and alum are successively added.

G. P. 288,318/14 Kieser. An insulating material for protecting refrigerating pipes and the like is made when 25 parts of wood shavings are mixed with a finely pulverized mixture of 2 parts of stearic acid and 2 parts ceresin, and heated to 90 deg. C.

U. S. 1,194,273/16 Carlitz. Sealing rings for fruit jars are formed of wood pulp or asbestos impregnated with glycerol and coated with pyroxylin.

G. P. 288,532/14 Reif. Plastic masses are made from fibrous materials and binders. The binders are made by the action of sulphur, sulphur chloride or nitric acid on oils, tars, or the like. The mixture is maintained at such a temperature that a reaction is effected. In the further course of the working process, the mixture is brought to the reaction temperature by continuous pouring in and drawing off of the mass, and then it is atomized before cooling.

U. S. 1,197,428/16 Bache. Wood or other fibrous material, for use in making bearings which are self-lubricating, is impregnated with a mixture of graphite in varying amounts with a vehicle formed of rosin 20, paraffin 100 and carnauba or myrtle wax 20 parts, with or without 3–4 parts of stearic acid, at a temperature of 400 deg., after heating the wood in vacuo.

U. S. P. 1,198,028/16 Harden. Waste paper, at least partially pulped, is mixed with long unground whole straw stems in water, sheets are formed from the wet mixture and dried. The air cells provided in the sheet by the straw render it effective as a heat insulation and for deadening sound.

B. P. 8,004/15 MacFarland. Seaweed, such as eel grass (Zostera marina), is boiled in a 2% solution of soda lye and the fibrous residue is washed and removed. Part of this residue is treated with dilute sulphuric acid, which removes mineral and other matter and converts the cellulose into hydro-cellulose. The soluble substances are washed out, leaving a somewhat fibrous and gelatinous mass; 30–50% of this material are mixed with 70–50% of the fibrous material which has been treated with the alkali only. It may be rolled into sheets and used as a heat-insulator.

U. S. P. 1,348,789/20 Ehr and Matteson. A plaster board composition consisting of hard plaster 50%, paper pulp 25% and moss 25%.

U. S. P. 1,357,647/20 Mohler and Ludekens. The process of making a wood-like article which consists in fermenting barley, separating therefrom the solid residue, boiling the cellulose in the residual liquid of the barley, grinding the mass and molding and baking the molded product.

U. S. P. 1,364,776/21 Magnani. A composition of matter comprising wood pulp and starch, mixed with rosin, wheat flour, linseed oil and water in substantially the proportions of, wood pulp 1 lb., starch 1 lb., rosin ½ lb., wheat flour ¼ lb., linseed oil 1 gill and water 1 quart.

B. P. 1,370,155/21 Rose. The process of forming a wood substitute, which comprises impregnating a layer of coir fiber combined with other fibers with rubber, compressing said layer, and vulcanizing the same.

COMPOSITIONS WITH GELATINOUS, ALBUMINOUS AND SIMILAR BASE

U. S. P. 950,392/10 Heydenhauss. Celluloid Substitute. Gelatin or glue 25, saturated solution of carrageen moss 10, dilute acetic acid 10, alcohol 10. The material is treated with formaldehyde.

U. S. P. 952,724/10 Berend. Plastic and elastic composition. Glue is dissolved in phenol and glycerol, emulsified with aniline and a resin acid such as shellac, and the emulsion is treated with anhydrous formaldehyde.

G. P. 217,508/08 Horn. Coating material. Albuminous substances in solution are treated with epichlorhydrin or the like, to secure pliancy.

U. S. P. 954,991/10 Olsson. Plastic composition. In a mixture of glue or gelatin with glycerol, calcium chloride or magnesium chloride is combined with a hardening agent (chromate) and a pigment, which will retard the hardening by the action of light. The material is molded to shape before hardening.

B. P. 28,598/09 Chanard. Plastic material, strong, hard, non-inflammable, substitute for ebonite, celluloid, etc., made by treating starch with acetic acid, powdering product, adding coloring matter, mixing hot with a solution made by mixing gelatin dissolved in water with resin dissolved in turpentine. Plastic material so obtained is cast or molded hot, then hardened and immersed in formol.

B. P. 9,190/10 Feuerbach. Manufacturing a fluid of plastic substance which retains its fluidity for a considerable time, by binding together fibrous material with a solution of glue, adding a hygroscopic substance such as glycerol, a tannning or hardening substance, resin or colophony in alkaline solution, and vegetable or mineral oil, and finally working up and heating the whole mass.

B. P. 7,735/11 Caldwell. Producing a gelatinous cellular material by beating a gelatinous mass to a foam with a body of gas and introducing a hardening agent.

B. P. 25,400/10 Timpe. Manufacturing a plastic substance from a carbohydrate and an alkali albuminate by kneading a mixture of the albuminate and the carbohydrate, such as starch, or cellulose hydrate dissolved in alkali until it becomes a tough mass, drying this mass, and finally pressing in molds under high pressure.

B. P. 29,075/10 Cox. Plastic composition. Horn or hoof meal is mixed with 5 to 16% of blood, excess moisture is removed by passing through rolls, and the mass is pressed into molds at 125 deg. C. at 2 to 5 tons per sq. in. There may also be added milk, turpentine, shellac, gum, bitumen or the like.

U. S. P. 1,027,121/12 Goldsmith. Thermoplastic composition formed from vegetable albuminoid, formaldehyde, and betanaphthol.

F. P. 425,204/10 Soc. Anon. Française de Chimie Industrielle. In the conversion of animal albuminous substances into incombustible plastic masses the albuminous substance is dissolved in an alkali, adding pigment if desired, and then agglomerating the mass by means of an agglutinant.

F. P. 424,820/10 Jacquelin. Substitute for glass, celluloid, etc., consisting of a mixture of fish glue, gelatin, murgrass, lichen, glycerol, sodium potassium silicate, 90% alcohol and glucose.

G. P. 242,466/08 Kuller. In the manufacture of plastic masses finely divided glue or gelatin is mixed with chalk or the like and various other substances are added.

G. P. 239,698/08 Zinsser. In the manufacture of artificial wood, chaff is separated from the enclosing albuminous and starchy substances, ground and compressed to desired shape, with gelatinous matter.

G. P. 245,726/10 Rausch. In the manufacture of a substitute for tortoise shell horn, or the like, claw chips or horn scraps are degreased in a potash solution, separated and cleaned with metal brushes. The mass is comminuted, washed and dried by pressing. The mass is then colored, dipped in water for 12 hours, and compressed without binder at 100 to 150 deg. C at a pressure of 150 to 200 atmospheres. The product is treated with tartaric acid and glycerol, and finally pressed at 40 to 50 deg. C.

G. P. 248,484/10 Proteine-Maatschappy. In the manufacture of plastic substances from carbohydrates and alkali albuminates, the latter are kneaded with a carbohydrate (e.g., starch or cellulose hydrates) in the presence of an alkali, with or without a filler, until a solid tough mass results, whereupon the mass is dried and pressed in forms at high pressure.

U. S. P. 1,041,229/12 Armstrong. Plastic composition, for printers' cuts, etc., formed of gelatin, wax, tannic acid, water, linseed oil, banana oil and molasses.

ADHESIVES

U. S. 1,114,819/14 Thoma. An adhesive filler for uniting inner and outer soles of shoes, is formed by friction-milling a mixture of wax tailings, rosin and fixed

vegetable or mineral oil with pontianak, and finally adding finely divided cork. Creosote may be added.

U. S. 1,115,988/14 Thoma. Adhesive for uniting inner and outer soles of shoes, containing wax tailings, dextrin and small particles of cork or leather.

B. P. 14,844/13 Vlles. An adhesive paste which does not putrefy consists of water, fecula, white dextrin, alum, starch, borax, white gelatin, corn flour, gum arabic, essence of wintergreen and hydrochloric acid.

U. S. 1,134,931/15 Thoma. A shoe-bottom filler is formed of resin, naphthalene and various other adhesives mixed with granular cork.

U. S. 1,137,043/15 Wood. A fusible adhesive for use in making paper walled receptacles is composed of gilsonite 30, linseed oil 4 and vaseline 15 parts. Parolite or elaterite may be substituted for gilsonite and China wood oil for linseed oil.

B. P. 6,445/14 Mulligan. An adhesive paste is made from a powder comprising ground manioc root well mixed with a non-poisonous metallic chloride such as magnesium chloride, or sodium chloride, or both, and with or without a small quantity of maize flour, farina, or the like. For use, hot water is added.

U. S. 1,153,574/15 Rovira. An adhesive formed of benzine 100, para gum 3–6 parts and 10 parts of a varnish made by dissolving celluloid in ammonium acetate and acetone, is used for coating paper with a thin layer of cork flour, for making mouth-pieces of cigarettes.

A. P. 9,409/13 Mensik. An adhesive is made by treating pulverized resin with salicylic acid or its salts.

U. S. 1,162,712/15 Schleicher. Talc 1, and 3.6 deg. Bé. Solution of water-glass 16 parts, are mixed, forming an adhesive for use either hot or cold for making veneer boxes, etc.

U. S. 1,171,905/15 Tompkins. Spent vegetable tanning liquor is concentrated and used as a road binder. It may also be used as an adhesive for molders' sand cores, for uniting wood, paper or pasteboard and for other purposes.

B. P. 26,231/09 Lehmann. Making a product intended to replace the glues made from leather, bones, and cartilage (chondrin) by treating the colloidal matters extracted from seaweed, from agar-agar or other marine algæ, with an acid such as acetic, and adding either an agglutinant such as dextrin or an astringent such as tannin.

B. P. 3,415/10 Kantorowicz. Making substances of high adhesive power swelling in cold water from flaked substances obtained from potatoes, or other starch-containing bulbs, roots, fruit, flour, starch flour, and the like, by grinding and mixing them with an alkali or with an acid, or with a substance liberating oxygen or with a hygroscopic substance.

B. P. 5,018/10 Greenwood. Making a mucilage by treating gum or mucilaginous solutions obtained from vegetable products, seeds, barks, rhizomes, or extracts from any of these, with tannic acid or extracts containing it.

G. P. 231,256/09 Curtins & Co. Addition to 217,257/09. In an adhesive for paper, sodium bisulphate is added to the sulphates of aluminum and magnesium.

U. S. 1,023,523/12 Neil. A glue is made of dry powdered chondrin and glutin.

B. P. 4,227/11 Warr. A mucilage prepared from seaweed by heating with water which may contain an alkali, such as soda ash, is used to bind the dust and prevent explosions in coal mines. A hygroscopic salt, such as calcium chloride, and an antiseptic, may be added. The mucilage is applied by spraying.

G. P. 237,752/09 Sadlon. Glue of good quality is obtained from chrome-tanned leather scrap, without detanning, by destroying the fiber structure with caustic alkali, the material being converted into a formless doughy mass.

CORK, LINOLEUM AND RELATED COMPOSITIONS

B. P. 9,867/09 Tugendreich. Composition cork. Cork is covered with a solution of one part of glue in 6 parts of boiling water, to which 0.7 parts of glycerol are added. The mass is then treated with a solution of 1 part chrome alum in 4 parts of boiling water. The mass is mixed and dried, and molded to shape.

U. S. P. 948,189/10 Snow. Linoleum formed from oxidized linseed oil 100, kauri gum 1, rosin 1.5, magnesia 85, asbestos 15, wood flour 45, coloring matter 50.

U. S. P. 948,572/10 Blaubach. Linoleum made by mixing ground cork or wood or jute, coloring material, boiled linseed oil, resin and kauri, pressing the mixture upon canvas or the like, disintegrating the product to form a granular mass, and pressing it upon canvas.

U. S. P. 957,594/10 Thuma. Plastic sheet having a fabric sheet with an outside layer of heavy canvas, a backing of pulp-like filler, such as wood pulp, leather dust, rubber scrap, jute, litharge, whiting and sulphur, united thereto and a low-melting hydrocarbon, all united into a leather-like sheet by heat and pressure.

U. S. P. 1,008,972/11 Lenhart. Cork composition, formed of finely divided cork 160; gum arabic 2; starch 1.5; gelatin 1; sugar 1; glue 2; glycerol 1.

U. S. P. 1,003,773/11 Merrill. Heat insulating material consisting of a mixture of dry cork and powdered asbestos.

G. P. 245,325/10 Reis Gesellschaft. Rice hulls, ground or powdered, are employed as substitute for cork or sawdust in the manufacture of linoleum, lincrusta, or the like.

N. P. 21,918/11 Magelssen. In the manufacture of a porous fireproof insulating mass, a porous cork mass saturated with a solution of a waterproof material such as a mixture of water-glass, and chalk, or the like.

Neth. P. 1,356,784/20 Oltmans. A pliant floor covering containing the reaction products of about 110-120 parts of glue, 60 parts of glycerine, a coagulating agent, 15 parts of nitric acid and 150 parts of wood flour, and a filling material.

U. S. P. 1,369,911/21 Brown. A new compositional matter composed of approximately 50% of ashes and fine cinders, 25% of asphalt and approximately 25% of finely cut waste broom straws or stalks thoroughly commingled, and a small amount of molasses.

U. S. P. 1,370,990/21 O'Connell. A process for making a covering for roofs, floors, walls, etc., which consists in heating asphalt to liquid form, in stirring coal ashes into the hot molten asphalt, in then applying heat to the commingled mass and stirring the same while being re-heated, and in stirring a mineral oil into the hot mixture.

U. S. P. 1,379,204/21 Norton. A method of producing stone-like shingles which comprises forming a series of thin, compressed sheets of asbestos, hydraulic cement, and sufficient water for setting the cement, stacking said sheets in a closed compartment, and maintaining an atmosphere of approximately 90% humidity in said compartment during the period of setting of the cement.

U. S. P. 1,403,786/22 Ingoldsby. A composition for making floor-tiling, etc., compounded of one-fourth of a pound of litharge, a half pound of whiting, one fourth to two thirds of a pint of boiled linseed oil and finely ground cocoanut shells.

U. S. P. 1,406,618/22 Davis. A composition of matter adapted to form tone boxes for phonographs, comprising 4 parts ground cork, 1 part asbestos, 1 part ground silica, 2½ parts magnesium oxid, and magnesium chlorid.

F. P. 1,411,906/22 Bourdariat. An improved building material consisting of 100 parts sea-wrack mixed with 15-25 parts of agglutinant.

COMPOSITION FOR PHONOGRAPH RECORDS

U. S. P. 944,474/09 Aylsworth. Sound record composition. Mixture of asphalt with copal gum, and the lead soap of the fatty acid of montan wax.

U. S. P. 947,777/09 Sanderson. Phonograph records. Barytes 33, terra alba 16.5, clay 16.5, flock 3, shellac 31. This plastic composition is applied as a coating over fibrous material attached to metal disc, in the manufacture of sound records.

U. S. P. 948,314/09 English. Phonograph records. Shellac 72, beta naphthol, nitro benzene, or nitro naphthol 8, and a filler, such as clay, silica, etc., 20.

U. S. P. 953,454/10 Aylsworth. Nitro-cellulose phonograph record.

U. S. P. 956,904/10 Sanders. Sound record made from cardboard sized with rosin and coated with a layer of plastic gramophone record material.

U. S. P. 956,905/10 Sanders. Making sound record tablets, see preceding abstract. The gramophone record material may contain, e.g., shellac and iron oxide.

U. S. P. 958,210/10 Aylsworth. Sound record having an outer layer of lead stearate, a resin gum and asphalt and an inner layer of sodium stearate, stearic acid, aluminum stearate and ceresin, with or without carnauba or other wax or ground wood or clay.

U. S. P. 962,878/10 Aylsworth. Phonograph record composition consisting of montan wax which has been subjected to prolonged heating at 260–282 deg. C. with a small amount of sulphur and freed from the gummy sediment thus produced.

G. P. 27,208/08 Winter. Material for gramophone plates from a mixture of viscose and a filler (e.g., heavy spar, infusorial earth), by adding thereto colophony or asphalt in finely divided form, and tar.

U. S. P. 1,002,505/11 Edison. Composition for sound records containing shellac 80% and commercial tetrachloronaphthalene 20% in the form of fibrous crystals distributed through the shellac. Dinitrotoluene or dinitro-benzene may be used instead of tetrachloronaphthalene, and a filler such as asbestos or cotton may be employed.

U. S. P. 1,017,032/12 Aylsworth. Composition for phonograph records, comprising an organic solid, e.g., Kauri gum, an inorganic salt, a fatty acid and asphalt.

U. S. P. 1,078,265/13 Edison. Phonograph records of wax-like material are surface-hardened by repeatedly dipping them in a solution of nitrocellulose in amyl acetate and allowing the solvent to entirely evaporate. Sodium silicate may be used instead of nitrocellulose and the silicate coating hardened with calcium chloride. Acetylcellulose also may be used.

U. S. 1,119,142/15 Edison. A phonograph record made with a surface portion of shellac and fibrous tetrachloronaphthalene and an underlying portion of montan wax and cotton fibers having about the same coefficient of expansion as the superficial portion.

U. S. 1,146,384–91/15 Aylsworth. Methods of molding phonograph records of resinous phenolic condensation products.

U. S. 1,146,413/15 Edison. Sound record tablets are made by placing a layer of powdered phenol resin and wood pulp in a mold, compressing to a compact mass of even thickness, then adding a layer of finely powdered phenol resin and further pressing while heated.

U. S. 1,146,414/15 Edison. Sound record tablets are formed with a thin surface facing of celluloid and a thicker backing of rubber.

U. S. 1,151,849/15 Aylsworth. Sound records are made with a body layer of wood fiber or other filler and a binder of phenolic condensation product and a surface layer of fusible phenol resin mixed with chloronaphthalene or other material which will increase its plasticity.

U. S. P. 1,158,659/15 Edison. Phonograph records are made from a mixture of diphenylamine 15, shellac 70 and acetanilide 2 parts.

U. S. P. 1,158,660/15 Edison. Phonograph records are formed of an emulsified mixture, of shellac with about 35% its weight of stearic acid or an emulsion of shellac with naphthalene and benzoic acid. A camphor-shellac mixture is too readily deformable by heat to give as durable a record.

U. S. P. 1,158,974/15 Beatty. In making gramophone record fillers such as graphite, wood powder, steel dust, lampblack or iron oxide are mixed with a condensation product of acetone, phenol and formaldehyde.

U. S. P. 1,167,468/16 Aylsworth. In making phonograph records the main portion is formed of a mixture of fusible phenolic resin with a filler such as wood flour, and the surface of the record is made of hard infusible phenolic resin sufficiently plastic when heated to be pressed and molded.

U. S. P. 1,170,391/16 Aylsworth. Phonograph records are made by mixing a fusible phenolic resin dissolved in alcohol, or other solvent with hexamethylene tetramine or other reagent which will harden the product on heating, and with an inert filler such as dry wood pulp; the solvent is removed by evaporation and the product after being powdered is molded and heated.

U. S. P. 1,175,728/16 Eichengrun. In making gramophone records the facing layer is formed of acetylcellulose mixed with a filler and a softening agent, e.g., dichlorohydrin.

U. S. P. 1,355,791/20 Berliner. The process of forming sound-records from a matrix which consists in forcibly projecting a plastic record surfacing material against the phonetic characters of the matrix to provide the same with a coating, uniting such coating by heat and pressure with a plastic base, subsequent cooling of the matrix effecting separation of the sound-record from the matrix.

U. S. P. 1,379,729/21 Stubner. A process of making a sound-recording composition by combining candelilla wax and a stearic acid in substantially the proportion by weight of one of the former to four of the latter and heating the mixture to approximately 230° F., then adding a magnesium salt thereto, then treating the same with sodium-aluminum hydroxid, and then adding paraffin in an equal amount to approximately 6% of the same.

U. S. P. 1,413,984/22 Harris. A process of manufacturing talking machine records which consists in permeating a disk of paper or similar material with a mixture of glue, dextrine and shellac and coating the disk on one or both surfaces with a facing of phonograph stock and pressing the resultant non-thermoplastic mass into record form.

VEHICLE TIRE FILLINGS OF VARIOUS COMPOSITIONS

G. P. 214,399/08 Schaar. Tire filling. Japanese glue is dissolved in glycerol, adding salicylic acid, tannin and lysoform.

G. P. 216,107/08 Schaar. Tire filling. Addition to 214,399/08. Modification of the original process with the addition of hexamethylene tetramine.

U. S. P. 948,845/10 Caldwell. Tire filling. Stirring a viscous mixture containing gelatine and glycerol into a form with air or other gas, adding a tanning agent in the presence of an oxidizing agent (air) and a restraining agent, such as sodium sulphite.

G. P. 225,277/08 Pneum. Modification of G. P. 214,399 and 216,107; use of animal instead of vegetable colloidal substances in manufacture of tire filling.

G. P. 236,728/10 Zimpel. In the manufacture of tire filling compound, glue or glue and gelatin are soaked in water, heated in a steam bath and mixed with borax solution. Linseed oil and train oil are boiled together and heated to about 140 deg. C. adding white lead. The two mixtures are poured together hot, and

further heated to the desired consistency. Hot alum solution is added to harden the mass. The product is used warm.

U. S. P. 1,025,000/12 Manley. Tire filling mixture made from gelatin 40, glycerol 40, balsam of fir 3; fine cork 5; potassium dichromate 12.

U. S. P. 1,036,170/12 Zimpel. Filling for tires, containing glue, linseed oil, shark oil and alum.

U. S. P. 1,038,891/12 Howser. Filler for rubber tires made from cork 1, sulphur 8.5, corn oil 30.5 parts.

U. S. P. 1,041,526/12 Suss. Filler for pneumatic tires composed of glue, water, sugar, sodium silicate and glycerol.

U. S. P. 1,351,670/20 Mayer. A tire filler, consisting of the following ingredients: 152 lbs. of sunflower seed oil, 32 lbs. of sulphur chlorid, 5 lbs. of calcium hydroxid, 4 oz. of soluble dies, and 8 lbs. of soap oil.

U. S. P. 1,369,626/21 Cuttitta. A tire filler comprising a mixture formed of the following ingredients: crude rubber, a compounding ingredient or filler, a vulcanizing ingredient, an accelerator, a leavener, and a vehicle, the mixture having minute air pockets distributed throughout the mixture thereby providing the mixture with a rebounding quality.

U. S. P. 1,376,973/21 Schmidtke. A tire filler comprising the following ingredients in proportions substantially as set forth; vegetable oil, 74%; magnesium oxid, 2.2% ultramarine, 2.2%; litharge, 2.2%; oakum, 1.9%; chlorid of sulphur, 17.5%.

ARTIFICIAL LEATHER

B. P. 491/11 Hide-Ite Leather Co. In making artificial leather or board, a mass of fibrous leather is incorporated with a mass of fine non-fibrous leather particles. These particles are substantially waterproof, but a waterproofing agent may be added if required.

B. P. 1,111/11 Hasenbring. Soft vulcanized fiber for soles and heels of boots and shoes, is treated by immersion for about 10 minutes in a bath composed of 2 parts by weight of linseed oil and 1 of petroleum, and then dried in the air.

G. P. 229,535/09 Reidel. Artificial leather is made from the compressed skin of animal fibers, treated with tannic acid, washed, treated with alumina soap, dried and impregnated first with a solution such as gutta-percha, balata, etc., in carbon disulphide, carbon tetra-chloride, chloroform, etc., and then with hydrocarbons, as benzine, benzol, etc., and finally ripened by the action of light.

G. P. 232,894/10 Ges. Patentverwertung. In making gum-like material or artificial leather, applying simultaneously upon the two surfaces of the fleece being run between rollers a thin cellular tissue which is fixed to the fleece during the process.

G. P. 238,252/09 Wawrziniok. Addition to 228,421. Making artificial leather by forming a felt band containing within it comminuted leather and, together with other substances, sufficient finely ground celluloid, nitrocellulose, or their equivalents, to agglutinate the leather powder and the other material with the felt, by the treatment with steam, gas, or sprayed volatile solvent.

G. P. 240,727/10 Lowei. Making leather-like masses by impregnating comminuted leather waste with caoutchouc solution, mixing the product with old gum powder, and compressing this mass in forms and heating under pressure.

G. P. 241,468/10 Reidel. Making artificial sole leather and strap leather by adding to the built up fleece of shredded fiber, albumen in the form of blood, and saturated soap solutions (also paraffin emulsions), and compressing the product.

B. P. 5,396/11 Campbell. A composition for use as an artificial leather, packing, or the like, consists of seaweed, with or without other vegetable matter, which has been boiled in ammonia to which is added fibrous material, powdered filling material,

and a glutinous or resilient binder, the whole being heated and agitated, and pressed and vulcanized. Oil may also be added to the mass before heating.

G. P. 247,060/11 Hahn. Making a leather product from split leather, by applying an adhesive and then solid or sludge-form fibrous material (paper, fabric, felt), applying again an adhesive, and then imprinting a graining.

U. S. P. 1,382,947/21 Beatty. A leather-like material comprising tanned coagulated viscose having fiber incorporated therein.

Australian P. 1,405,600/22 Lansdown and Magnus. An improved method of and means for the treatment and utilization of scrap or waste leather consisting of reducing the same to a coarse powder, cleansing the powdered leather with oxalic acid adding thereto an adhesive and drying composition consisting of liquid glue, boiled linseed oil, carbolized oil and oil of cloves.

Can. P. 1,409,301/22 King and King. A leather substitute for producing a waterproof sole for shoes consisting of mixing and boiling together, asphalt, leather dust, cotton fiber and linseed oil, and thereafter subjecting the mass to a hydraulic pressure to form the same in a sheet.

ARTIFICIAL SILK

Fr. 424,293/10 Wetzel. An improvement in making copper-ammonia-cellulose and its derivatives, consists in limiting the ammonia content to 3%. The advantage is in the greater viscosity of such solutions.

B. P. 4,744/11 Koller. Solutions and compositions are obtained by treating cellulose acetate, or mixtures containing it, with mono- or poly-hydric phenols and trichlorethylene or perchloroethylene, or both. The solutions and plastic products are suitable for covering or impregnating fibers, fabrics, leather, paper, etc., with waterproof and lustrous coatings, and for producing artificial silk, films, incandescent filaments, etc.

G. P. 245,575/11 Traube. Production of cellulose solutions with alcohol solutions of the alkylenediamines. A 5% ethylenediamine solution, saturated with copper hydroxide, quickly forms cellulose solutions of high viscosity. The precipitation of the cellulose is effected by a small amount of acid.

G. P. 244,510/11 Ditzler. In making artificial silk, films, and the like, with an ammoniacal copper oxide cellulose solution, all the operations to the point of the precipitation are carried out *in vacuo*, in a neutral atmosphere or in an isolating liquid. In this way oxidation is prevented.

U. S. 1,028,748/12 Lederer. Making filaments from acetylnitrocellulose.

U. S. 1,029,341/12 Bronnert. Dissolving formylcellulose in lactic acid.

U. S. 1,030,311/12 Koetschet. Acetylizing cellulose with acetic anhydride under reduced pressure.

B. P. 6,241/11 Glanzstoff. Cellulose formate is obtained by precipitating cellulose hydrate from ammoniacal copper cellulose, nitrocellulose, and viscous solutions in an unshaped condition, and dissolving it in formaldehyde as described in 15,700/10.

G. P. 246,651/10 Wohl. Making viscous solutions of acetylcellulose.

G. P. 246,967/10 Doerflinger. Making lacs and producing films, fibers, and the like, from aliphatic esters of cellulose, especially acetylcellulose, by dissolving in diacetone-alcohol with or without the addition of diluents; nitrocellulose can also be added to the solution.

B. P. 7,442/11 Soc. Anon. A brilliant sheet of cellulose ester formed by evaporating a solution on a polished surface is reinforced with a thin textile fabric by impregnating the fabric with a solvent of the ester and pressing it on the ester sheet.

U. S. 1,031,616/12 Benrath. A lustrous thread is made by coating with acetylcellulose, metal powder and coloring matter.

G. P. 248,559/09 Lederer. Modification of the process of making solutions for artificial threads and the like by dissolving nitro-and acetyl-cellulose in common in acetylene tetrachloride and acetone, whereby the acetylene tetrachloride is replaced by chloroform and the aceton by acetic acid.

B. P. 8,313/11 Glanzstoff-Fabr. Cellulose formate solution is produced by dissolving artificial silk refuse in formic acid, adding lactic acid, and then distilling off the excess of formic acid. A viscous syrup remains which can be drawn into threads and hardens on cooling and standing into a solid plastic substance.

B. P. 11,714/11 Compagnie Cellulose. Baths containing an alkali arsenite and caustic alkali are used for precipitating ammoniacal copper solutions of cellulose. These products contain all the copper of the original solution and may be freed therefrom by treatment with acid, as dilute sulphuric. Threads, films, fabrics, plastic masses, etc., may thus be obtained.

B. P. 9,336/11 Palatine Artificial Silk Co. Cellulose solutions containing copper compounds are produced and manipulated, up to the time of precipitation, in vacuo or in the presence if an inert gas such as nitrogen or an isolating liquid such as benzene, to prevent oxidation. Solutions of viscose and cellulose acetate may also be subjected to such treatment.

U. S. 1,041,112/12 Lindsay. Dissolving acetylcellulose in a mixture containing equal amounts of methyl alcohol and pentachloroethane.

U. S. 1,041,113/12 Lindsay. Making plastic compounds of acetylcellulose by incorporating ethyl-para-toluenesulfoneamide and triphenyl phosphate with acetylcellulose solution in acetone, adding methyl alcohol, allowing the mixture to gelatinize and working up the mass.

U. S. 1,041,114/12 Lindsay. Acetylcellulose is dissolved in a mixture of trichlorohydrin and alcohol.

U. S. 1,041,115/12 Lindsay. Dissolving acetylcellulose in camphor, triphenyl or tricresyl phosphate and methyl alcohol.

U. S. 1,041,116/12 Lindsay. Ethyl alcohol replaced the methyl of the preceding patent.

U. S. 1,041,117/12 Lindsay. Dissolving acetylcellulose in tetrachloroethyl or trichloromethylacetanilide, triphenyl or tricresyl phosphate and methyl alcohol.

U. S. 1,041,118/12 Lindsay. Ethyl alcohol is used instead of the methyl in the preceding patent.

U. S. 1,041,587/12 Borzykowske. Making dyed cellulose acetate by treating cellulose simultaneously with a dye and acetylizing reagents.

G. P. 250,421/10 Massmann. Producing collodion solution serving as binding agent for printing colors as well as for making artificial silk, by using a mixture of equal parts of benzene and alcohol as the solvent.

F. P. 1,398,525/21 Lance. An artificial silk comprising a cellulose ester having a metallic resinate with a high fusion point, said resinate not exceeding 20%.

PAPER

G. P. 229,390/09 Hellwig. Making cellulose from wood waste, bark, straw and similar crude materials by treatment with a solution of calcium chloride and hydrochloric acid, and with potash or soda. After removal of the waste lye and the neutralization of the disintegrated mass (with lime water) the product can be worked directly to pulp or paper

U. S. 1,009,790/11 Ross. Wall paper is formed of paper stock having granules of sawdust incorporated therein so that the paper has a rough or pebbly surface.

U. S 1,010,038/11 Tritzsche. In treating paper in the preparation of imita-

tion and stained glass, first coating tissue paper on one side with thick varnish, then embossing it, coating the opposite side, and finally filling in the embossings and smoothing them over.

G. P. 233,665/10 Petsche. In recovering paper fiber from old printed stock, the initial material, shredded and treated with an alkaline solution is spread out upon a sieve and the impurities such as dye, glue, loading, etc., washed away with water.

B. P. 2,455/11 Pink. In coating corks with parchment, they are first coated with a solution of cellulose in ammoniacal copper oxide. The copper is then removed in a bath of acid, and the coating is converted into parchment by treatment with sulphuric acid.

B. P. 3,181/11 Dobson. In making paper pulp from chemical wood cellulose, more particularly unbleached sulphite or soda cellulose, the cellulose is bleached by introducing it dry into concentrated bleaching liquor.

G. P. 243,308/11 Grosshein. Making variegated glass paper by mixing finely pulverized glass with lac to form small glass particles, and applying them to the paper by rolling.

G. P. 244,818/11 Leuchs. In the impregnating of fibrous material, especially paper, with sulphur, finely divided sulphur (milk of sulphur) is added to the material, the mass is mixed, and the desired articles are formed from such mass.

Nor. 21,853/09 Sparre. Paper is obtained from sawdust by treating it at 70–75 deg. with soda and then under high pressure, as usual, with an acid or an alkali, until it forms a homogeneous mass, which is bleached and worked up in the paper machine.

B. P. 7,099/11 Boult. The edges of sheets of unsized cardboard, blotting-paper, or the like, are strengthened to prevent tearing by impregnating them with products which are insoluble or soluble only with difficulty in water. Varnishes, greasy products, solutions of resinous soap, glue or gelatin, casein, vegetable gluing material, etc., treated or not by astringent or precipitating agents such as tannin alum, formol, etc., may be used.

PACKING MATERIAL

U. S. P. 1,349,737/20 Somerville. Packing material comprising a mass of loose fibers, saturated or impregnated with orange shellac dissolved in methyl alcohol and containing glycerin.

U. S. P. 1,355,830/20 Goodsell. A compound for a plastic metallic packing consisting of a mixture of granulated Babbitt metal, brown mica flour, beeswax, lubricating oil, and a metallic wool binder for the whole.

B. P. 1,367,003/21 Bailey. A packing composition, comprising substantially 28 lbs. pulverized white metal, 1 lb. powdered talc, 1½ lbs. powdered graphite, ½ lb. powdered cork, 1½ lbs. of tallow, 1 lb. carded asbestos, and 1-2 lbs. finely powdered mica, according to the use to which the packing is to be put.

U. S. P. 1,371,016/21 Bennett, Palmer, and Wedlock. A method of producing rigid, cellular, heat insulating material consisting in producing a dough having per hundred pounds approximately the following ingredients and proportions, viz: Asphaltum 27.0 lbs., infusorial earth 11.0 lbs., magnesium carbonate 5.0 lbs., crude rubber 26.9 lbs., sulphur 14.9 lbs., sulphur treated corn oil 2.6 lbs., petroleum tailings 5.8 lbs., bicarbonate of soda 6.0 lbs., alum 0.8 lbs.; heating the mixture under pressure for a period and to a degree sufficient for vulcanization, rolling the material while still hot and finally cooling it.

U. S. P. 1,372,664/21 Aslatt. A plastic coating composition comprising by measure, two parts comminuted chalk, one part comminuted clay, nine parts comminuted textile fiber.

U. S. P. 1,383,943/21 Harris. A metal packing comprising a metal alloy in granulated form, a metal alloy in wool form, asbestos, a lubricating substance and means for holding the particles of the metal alloy and the asbestos apart.

U. S. P. 1,409,276/22 Benjamin. A resiliently compressible tough, stable, heat-conducting, non-sticking gasket or packing material consisting of non-combustible, wholly mineral filling material, including powdered aluminum and graphite, held and protected by rubber united with phenolic condensation product in the presence of sulphur, by heat and pressure applied while the condensation product is in primary soluble state, and said sulphur being less than 5% and more than 1% of the rubber-sulphur; said condensation product being less than 11% and more than 8% of the rubber-condensation product; and said rubber-condensation product being less than 40% and more than 20% of the whole, the completed material containing less than 1% of uncombined sulphur.

RUBBER AND RUBBER COMPOSITION

B. P. 16,353/10 Lapisse. Felt is impregnated with India rubber mixed with a small portion of tar to facilitate the penetration of the rubber.

B. P. 18,497/10 Clarkson. In the vulcanization of India rubber by means of sulphur or other agent, there are added such loaders as diatomite, kieselguhr, fossil-meal, infusorial earth, granite, chips, or analogous material.

B. P. 8,591/10 Whitley. Producing a resilient compound by submitting dry cork to great pressure, grinding, intimately mixing with rubber or rubber waste in any proportion, rolling or pressing the product, and finally vulcanizing.

U. S. 100,781/11 Collier. A flexible composition consists of an intimate mixture of vulcanized India rubber and individual short lengths of thread composed of fibers tightly twisted together. For heavy pneumatic tires 20–30% of cotton threads are combined with the rubber.

B. P. 19,328/10 Metcalfe. The fibers of a batt of cleansed cottonwool are separated and impregnated with a solution of rubber and sulphur, passed between rollers and vulcanized. The mass contains about 1 part of cotton and 2 parts rubber.

B. P. 23,727/10 Beaver. In treating India rubber, sheets, strips or the like are exposed to rays which lie between certain limits of the spectrum, instead of being exposed in the dark as hitherto. Red and ultraviolet rays are excluded.

G. P. 237,789/10 Pahl. In the coagulation of the milk sap of plants yielding caoutchouc, carbon dioxide is used, preferably by leading the gas into the sap. The coagulation is effected instantly and the resulting gum is especially tenacious.

G. P. 240,164/10 Baermann. In making a firm caoutchouc plaster, non-irritant and antiseptic, resin acid esters are employed instead of resins and resinous acids.

G. P. 242,221/11 Vulcan. Repairing pneumatic tires or the like with an agglutinant material composed of Para gum, gutta-percha, antimony-cinnabar and carmine.

G. P. 244,329/11 Heinemann. Textile materials, for use as dress shields and the like, are impregnated with perborates dissolved in aluminum solutions, and then coated with caoutchouc solution containing 5% anhydroformaldehydeaniline. In contact with moisture in the heat, as perspiration, a slow uniform evolution of oxygen results.

B. P. 5,036/11 Akt. Ges. Mann. A strong knitted fabric is impregnated with or imbedded in rubber to make tires, envelopes of balloons, etc.

G. P. 243,346/09 Ostwald. Addition to 221,310. Preventing the rapid decay of rubber goods by impregnating with neutral or basic aromatic or heterocyclic nitrogen containing compounds, alkaloids, or their solutions or mixtures. e.g., a pneumatic tire is coated within and without with a 10% solution of dimethylaniline in benzene.

G. P. 244,359/10 Lapisse. Felt is impregnated with caoutchouc solution and compressed into desired products. Upon releasing the pressure the caoutchouc forms a layer upon the surface of the felt.

B. P. 6,910/11 Kemp. A composition for treating rubber goods such as tires, or for waterproofing canvas, leather paper, etc., consists of Para rubber solution, French chalk, petrol, benzoline, wood naphtha and coloring matter.

U. S. 1,032,428/12 Reynaud. A product of rubber, oil of turpentine and sulphuric acid, having the physical properties of natural rubber.

B. P. 11,624/11 Pfleummer. Rubber froth is made by kneading 10 parts rubber with from 0.20 to 1 part sulphur or antimony sulphide, vulcanizing under 80–300 atmospheres, and then relieving the pressure. If benzene 0.25 part is added, less pressure is required. The enclosed gas is increased by adding porous material such as kieselguhr or short fibers.

U. S. 1,041,262/12 Farkas. A plastic mass for making incandescent lamp filaments is formed from powdered black oxides of chromium, molybdenum sulphate and rubber solution.

U. S. 1,038,950/12 Pfleummer. Making hot vulcanized froth from India rubber, gutta-percha and balata.

B. P. 1,357,845/20 Claessen. A method or process of treating bark shavings from rubber trees consisting in grinding and masticating the bark shavings between heated rollers so as to knead the rubber with the barky material, and convert the whole into a doughlike or plastic material, mixing with this plastic material a vulcanizing agent and other rubber, and then vulcanizing the resultant mixture.

U. S. P. 1,360,744/20 Hazeltine and Gregory. A process of producing a rubber-like substance consisting of mixing fish oil 80 parts, sulphur 20 parts, expelling practically all air and moisture, subjecting the mixture to approximately 170° C. under pressure for approximately 2 hrs., meanwhile agitating the mixture.

U. S. P. 1,363,229/20 Burdette. The process of forming a flexible composition by mixing thoroughly raw rubber, a vulcanizing agent, a vulcanizing accelerator, fibrous material, petrolatum, and the product obtained by devulcanizing an intimate mixture of vulcanized rubber and gilsonite and then vulcanizing the mixture so formed.

U. S. P. 1,364,055/20 Boggs. As a new vulcanized rubber composition, consisting before vulcanization, of 100 parts of rubber mixed with 28 parts of selenium, 4 parts beta-napthylamin, 25 parts litharge, 4 parts paraffin, and 130 parts of zinc oxid and whiting.

U. S. P. 1,370,965/21 Hartong. A process of compounding rubber which consists in adding to rubber, water carrying in suspension hydroxid of aluminum, mixing the water and aluminum hydroxid with the rubber, driving off the water, and heating the mix with a vulcanizing agent to effect vulcanization.

U. S. P. 1,371,663/21 Bedford. A process of curing rubber which consists in incorporating into a caoutchouc mix a sulphur-nitrogen compound produced by reaction of sulphur with paranitrosodi-methylanilin and heating the resulting mixture with a vulcanizing agent.

U. S. P. 1,374,231/21 Porzel. A process of treating vulcanized rubber consisting of reducing the same to a finely divided state under conditions of exclusion of oxygen, adding thereto a small quantity of new, unvulcanized rubber sufficient merely to film the particles of old rubber, which new rubber has been dissolved in an excess quantity of solvent sufficient to distribute said new rubber over said particles, driving off said solvent, and forming and vulcanizing in the usual manner.

U. S. P. 1,377,152/21 Bedford and Kelly. A method of treating vulcanized scrap rubber which consists in boiling scrap rubber with caustic, washing with water to remove caustic, solubilizing the purified material by heating with a high boiling solvent, dissolving the solubilized mass, precipitating the rubber, dissolving the

precipitate in carbon-tetrachlorid, passing chlorin into the solution and recovering the product.

U. S. P. 1,379,149/21 Wichmann. A process of making a rubber-like substance, comprising macerating the fleshy parts of the members of the cactus family, heating the same above the boiling point of water, extracting the juice therefrom, adding a catalyzer consisting of approximately 10 ounces of sodium tungstate, 3 ounces of molybdic acid, and 3 ounces of calcium molybdate, concentrating the juice, adding a solution of 5 pounds of Pará rubber dissolved in turpentine, 2 1/3 pounds of raw linseed oil, and a molten solution of 25 pounds of asphaltum mixed with 5 pounds of sulphur to the concentrated juice, and drying and oxidizing the resulting mass, the quantities of reagents enumerated being based on 2000 pounds of cactus.

U. S. P. 1,379,150/21 Wichmann. A process of making a rubber-like substance, comprising macerating the fleshy parts of the yucca plant, heating the same, extracting the juice therefrom, adding a solution of Pará rubber, linseed oil, and a mixture of asphaltum and sulphur, boiling the juices and drying and oxidizing the resulting mass.

U. S. P. 1,379,743/21 Chertoff. A fluid rubber-compounding mixture, consisting of a resin, pine, and palm oil incorporated in the presence of heat to effect solution, fluid at normal temperatures.

B. P. 1,380,640/21. A process of preparing raw rubber of high grade directly from rubber latex in a simplified manner and with the omission of evaporative drying or smoking which consists in the combination of several consecutive and, when so employed, conjointly operative treatments, as follows: first, treating the latex, as soon as practicable after being tapped from the rubber trees, with a dilute aqueous solution of alkalized phenol to preserve the latex in a fluid and sound condition for any required length of time prior to coagulation; second, adding thereto a dilute solution of a suitable acid in sufficient quantity to neutralize the alkalinity of said preservative treatment and acidify the latex, whereby nascent phenol is liberated and energetic coagulation of the contained rubber in the latex takes place, the bulk of the impurities originally contained in the latex remaining in solution is mother liquor; and third, subjecting the coagulum of rubber thus obtained to a mechanical dehydrating treatment.

B. P. 1,381,455/21 Davidson. Raw rubber which has been coagulated by an acidified aqueous solution of a soluble salt of magnesium, from latex which has been preservatively treated with an alkalized phenol or phenoloid.

U. S. P. 1,384,773/21 Molony. As a new article of manufacture hard rubber dust produced from soft vulcanized rubber containing fabric by reducing the soft rubber scrap to pieces, impregnating the contained fabric with sulphur, subjecting them to a vulcanizing temperature for a sufficient length of time to vulcanize the soft rubber hard, grinding the resulting hard rubber and fiber, and separating the fiber from the hard rubber.

U. S. P. 1,395,413/21 Hoffman and Juve. A composition of matter comprising vulcanized rubber through which is distributed finely-divided lead whose individual particles are immediately surrounded by rubber containing petrolatum.

U. S. P. 1,396,837/21 Hartong. A method of mixing rubber products, which consists in emulsifying glue with water and a small proportion of pine-oil, adding gas-black to the emulsion, and incorporating the whole with the rubber.

G. P. 1,399,473/21 Graf de la Rosée. A process of manufacturing caoutchouc-like substances, consisting in melting resins with an addition of chlorid of calcium, subjecting the molten mixture to a distillation process with further addition of chlorid of calcium in connection with chlorid of lime, mixing the thereby obtained oils with India rubber, and subjecting this mixture to the usual vulcanizing process.

U. S. P. 1,399,789/21 North. In the manufacture of rubber goods containing glue and carbon black, the method of which consists in forming a water gel of the

proteid, emulsifying the gel with benzol, thoroughly mixing carbon black therein and then incorporating the whole into rubber.

U. S. P. 1,400,231/21 O'Brien. The process of incorporating glue into a rubber compound, the improvement which consists in working the rubber to plasticize the same in the presence of glue containing water insufficient in amount to plasticize it at ordinary temperatures but sufficient in amount to plasticize it in the working operation, the temperature of which is not permitted to exceed 300° F.

U. S. P. 1,405,439/22 Randall. A method of compounding rubber with a substance normally existing as an impalpable powder and drying it to produce a friable, granular or lumpy condition, and incorporating the dry, granular substance with rubber.

U. S. P. 1,406,197/22 Levinstein. A process of vulcanization which consists in intimately mixing crude rubber with a vulcanizing agent comprising barium thiosulphate and heating the same to produce a vulcanized compound combined with inert and stable filling material.

U. S. P. 1,409,275/22 Benjamin. A plastic article containing inert non-conducting comminuted material having the particles thereof coated with a primary condensation product of the phenol-formaldehyde type, intimately mixed with a vulcanizable gum, a vulcanizing agent, and an additional inert non-conducting filler; said mixture being vulcanized to form a solid article; the amount of sulphur being less than 11% and more than 1% of the rubber-sulphur; the amount of the condensation product used for the coating material being not more than one-half by weight of the comminuted material coated thereby and not more than 30% of the total rubber and condensation product constituting the binder; and the inert non-conducting filler being not more than 94% of the total final product.

U. S. P. 1,409,277/22 Benjamin. A resiliently compressible tough, stable, non-conducting gasket or packing material consisting of non-conducting, wholly mineral filling material, held and protected by rubber united with phenolic condensation product in the presence of sulphur, by heat and pressure applied while the condensation product is in primary soluble state, and said sulphur being less than 3% and more than 1% of the rubber-sulphur; said condensation product being less than 11% and more than 8% of the rubber-condensation product; and said rubber-condensation product being less than 40% and more than 20% of the whole.

RUBBER SUBSTITUTES

Fr. 434,587/11 Badische Fabr. Making caoutchouc-like substances by heating isoprene and its homologs with very small amounts of organic or inorganic acids or acid-reacting compounds or with sulphur, polymerization resulting.

Fr. 434,989/11 Bayer Co. Caoutchouc-like substances are obtained by the action of metals of the alkalies or alkaline earths or mixtures, compounds and amalgams thereof, on erythrene at the ordinary or raised temperatures.

Fr. 435,076/11 Bayer Co. Making caoutchouc, its homologs, and analogs, by the action of indifferent organic substances such as albumen, amides, urea, glycerol, etc., on erythrene.

G. P. 243,075-6/10 Harries. Isoprene can be obtained from dihalogenides or halogenhydrides of isopentane by reaction with basic oxides or hydroxides at temperatures above 200 deg., best at about 600 deg., or the above named compounds are conducted as vapors over carbonates or salts of organic acids, or are mixed with carbon dioxide or organic acids and passed over basic oxides or hydroxides.

B. P. 5,395/11 Cambell. A substitute for rubber is made by boiling crushed seaweed in ammonia, drying, adding an oil such as resin, naphtha, or terpene oil, then a vulcanizing substance and finally a binder (25% of seaweed) such as

pontianak, jelutong, gutta-percha, or reclaimed rubber waste, the whole being heated, dried and pressed. Before drying a preservative such as wood extract, tannin, etc., may be added.

B. P. 6,540/11 Bayer Co. Synthetic caoutchouc is obtained by heating, with or without the addition of polymerizing agents, mixtures of the hydrocarbons specified in 15,254, 17,734 and 25,850/10. In an example a mixture of isoprene and erythrene is heated alone.

Fr. 417,275/10 Badische. Beta, gamma-dimethyl-alpha, gamma-butadiene is made by leading vapors of pinacol or pinacolin over granulated aluminum at about 400 deg. The distillate contains besides water a product which upon distillation yields more than 70% of the theoretical yield of the above butadiene.

Fr. 419,316/11 Bayer Co. First addition 13,931/11. Making caoutchouc-like substances by the polymerization of mixtures of isoprene, erythrene, and other hydrocarbons of like constitution, in the presence or absence of polymerizing agents.

G. P. 435,312/11 Badische Fabr. Isoprene is obtained from isopentane by adding a halogen and then splitting off a halogen hydride.

G. P. 235,423/09 Badische Fabr. Making a caoutchouc-like substance by heating erythrene (divinyl) with or without the addition of an agent facilitating the polymerization. The temperatures may vary within wide limits.

G. P. 235,686/09 Badische Fabr. Making caoutchouc-like substances by heating substances having a nucleus of 4 carbon atoms with 4 free valences, wherein the valences are partly satisfied with hydrogen and partly with alkali residues, with the exception of erythrene, isoprene and beta-gamma-dimethylbutadiene, with or without the addition of diluents or catalysts.

G. P. 246,443/10 Lilienfeld. Plastic masses are made by heating wood oil, or the wood oil fatty acids or their substitution products, esters, or salts with amino derivatives of aromatic hydrocarbons with a suitable condensing agent in the presence of water. According to the proportion used and the time of reaction products are obtained resembling thickened oils, caoutchouc, gutta-percha, balata, celluloid, or resin.

G. P. 247,144/11 Bayer Co. In making isoprene and erythrene, the quaternary ammonium halogenides or hydroxides obtained by the exhaustive methylation of alphabeta-dimethyltrimethylenamine and beta-methyltrimethylenamine, or in any other manner, are converted into a alphabeta-dimethylallyidimethylamine, and alpha-methylallyidimethylamine, and these products are again subjected to the same decomposition. Both processes may be united in one.

U. S. 1,031,837/12 Caroselli. A rubber substitute is made from oxidized oils and formaldehyde.

U. S. 1,033,179/12 Kyriakides. Making piperylene by passing vapors of amylene oxide over heated aluminum silicate in vacuo.

U. S. 1,033,180/12 Kyriakides. Making isoprene by passing valeraldehyde vapors as above.

U. S. 1,033,327/12 Kyriakides. Making erythrene by passing vapors of butyraldehyde as above.

U. S. 1,033,328/12 Kyriakides. Making beta-gamma-dimethylbutadiene by passing vapors of hexylene oxid as above.

B. P. 8,613/11 Kelly. In making an India rubber substitute, oil-bearing seed, gummy peat, seed husks, or plants containing cellulose are first boiled in an alkaline solution such as lime, a semi-plastic material resulting. The product (20 parts) is heated at 450–600 deg. F. with crude or oxidized vegetable oils (70 parts), or it may be heated at 100–200 deg. F. with nitric acid, or nitric and sulphuric. It is then mixed with 1–5% of sulphur, or a compound such as potassium sulphate. A water and fire-proof cement is made by adding 10–30% chalk or cement.

G. P. 248,178/11 Teerverwertung Ges. A caoutchouc-like substance is made by

the action of sodium on hydrocarbons obtained from the distillation products of coal.

G. P. 248,399/11 Bayer Co. Facilitating and completing the polymerization of butadiene, its homologs and analogs, for conversion into caoutchouc or caoutchouc-like substances by operating in the presence of natural caoutchouc or substances of the caoutchouc class.

B. P. 10,420/11 Desouches. Making rubber substitutes by saturating cork, sawdust, or other powdered cellulose material with heavy petroleum or gas-tar oil, and mixing with an elastic mixture such as gelatin and glycerol, or rubber and resin oil.

B. P. 10,826/11 Badische Fabr. Diolefins, some of which may be used in producing caoutchouc, are made by treating dihalogen paraffins, monohalogenalkylenes, and monohalogenmonohydric alcohols with a chloride of barium, nickel, or lead, aluminum oxide, or calcium hydrate, whereby a halogen hydride or halogen hydride and water split off.

Fr. 438,789/12 Chem. Fabr. Schering. Obtaining isoprene with a good yield by heating nopinen to a high temperature.

G. P. 249,030/10 Bayer Co. Addition to 235,311. Instead of an acid salt of sulphuric acid an acid salt of di- or poly-sulphonic acids is used as the water eliminating agent in the conversion of pinacone into the dimethylbutadiene.

G. P. 250,086/11 Bayer Co. Addition to 235,311. Pinacone is converted into the dimethylbutadiene with the employment of acid-reacting neutral sulphates instead of the acid salts of sulphuric acid specified in 246,660.

U. S. 1,035,788/12 Heinemann. Obtaining elastic artificial caoutchouc from isoprene to which has been added a protein compound, e.g., keratin.

U. S. 1,036,875/12 Merling. Making isoprene from alpha-beta-dimethylallyl-dimethylamine.

U. S. 1,036,876/12 Merling. Making erythrene from alpha-methylallyldimethylamine.

U. S. 1,037,158/12 Lilienfeld. Making a substitute for oils, caoutchouc resins, etc., by heating together wood oil, ortho-toluidine and zinc chloride.

U. S. 1,038,359/12 Harries. Making erythrene by treating butylene bromide with soda lime.

Fr. 439,570/12 Reinicke. In making a substitute for ebonite, a viscous mass is obtained by digesting ground caoutchouc scrap with oil, this product is mixed with inert substances such as slate powder or powdered leather or the like, and also with cheap oil and sulphur, whereupon the mixture is vulcanized, ground, and mixed with oil, wax, and resin, and again vulcanized.

U. S. 1,039,741/12 Hofmann. Treating synthetic by caoutchouc with alkaline compounds to prevent its deterioration.

Fr. 440,130/12 Badische Fabr. Making isoprene by conducting dimethylallene, in the heat and in vacuo, over catalysts such as aluminum or compounds containing it.

CELLULOSE

B. P. 5,552/11 Rosenblum. G. P. 252,321/11 Rosenblum. In making cellulose from green pine wood, fir, poplar, etc., straw, hemp, grasses, etc., ammonia is added to the lye or to calcium bisulphite, thereby increasing the pressure.

B. P. 11,489/11 Pfiel. Cellulose is obtained from material in a finely divided state, such as sawdust, nettles, hops, etc., by boiling for a short time with dilute caustic soda until the encrusting substances are swollen up and at the most only partly dissolved, and they are then mechanically removed from the fiber.

G. P. 248,225/11 Saylor. Making cellulose from resinous wood with the separation of turpentine and resin by mixing with a small amount of caustic soda in a

closed vessel in vacuo, and then heating externally and internally with steam under pressure, and, after removal of the turpentine and resin by increasing the steam pressure, the wood is converted in the known manner into cellulose.

G. P. 248,275/11 Aktschourin. In making a brown wood mass (half-cellulose) from resinous woods, a dilute alkaline solution is first allowed to act at reduced temperature and under pressure. The encrusting constituents of the wood are not decomposed, but the resins are saponified and the colophonium is partly separated as an emulsion. After cooling, the latter are separated from the lye by filtration and the wood is then heated with the filtrate under high temperature and pressure.

CONDENSATION PRODUCTS

U. S. 941,158/09 Baekeland. A phenol-formaldehyde condensation product, with a fibrous substance, such as asbestos, paper or cloth, and graphite or talc as lubricant, is used for packing in steam fittings.

U. S. 939,966/09 Baekeland. A comminuted partial reaction product of formaldehyde and phenol is molded with a filling material, as asbestos or wood pulp, transformed into an insoluble and infusible final condensation product by heating and provided with a surface layer containing a large per cent of the final condensation product.

U. S. 942,852/09 Baekeland. Wood cell tissue is impregnated with an anhydrous condensation product of phenol and formaldehyde, which is then hardened in the wood by simultaneous application of heat and pressure.

U. S. 942,699/09 Baekeland. Phenol and formaldehyde (40% solution) about equal parts by volume are combined, the reaction product mixed with a filling material, as asbestos, wood fiber, rubber, casein, lamp black, mica, zinc oxide, barium sulphate, nitro-cellulose, talc, etc., molded into the desired form and rendered insoluble, hard and infusible by the application of heat (100°–140°) and pressure. In the process water is abstracted by a metallic salt, as calcium chloride.

U. S. 942,700/09 Baekeland. Phenol is reacted on with about an equal volume of formaldehyde (40% solution), water being separated from the initial condensation product by dehydrating agents, and the reaction arrested when the product has been transformed into a mass which is solid at all temperatures and hard when cold, soft and elastic when heated but infusible, insoluble in glycerol and formaldehyde or mixtures of these and swelling in phenol and acetone without complete solution therein.

U. S. 942,809/09 and **G. P. 281,454/09 Baekeland.** Phenol is reacted on with formaldehyde in the presence of a base as ammonia, ammonium carbonate, caustic alkalies, carbonates of sodium or potassium, aniline, pyridine, hydroxides of barium, calcium or strontium, amines, amides, alkali sulphides, acetates, cyanides, phosphate, borate, etc., serving as a condensing agent, the latter being less than 1/5 of the equimolecular proportion of the phenol used, water being separated from the mass and heat and pressure applied to harden the product.

G. P. 217,560/08 Blumer. A shellac substitute is made by treating with oxidizing agents the alkali-soluble resin-like condensation products obtained in the known manner from phenols and formaldehyde, acid or alkaline. The products are odorless and unaffected by air and light.

G. P. 219,209/07 Knoll & Co. Resin-like condensation products, readily soluble in alcohol are produced by the condensation of phenols with formaldehyde in the presence of neutral, acid, or alkaline-reacting salts, steam or vapors of such agents as have a solvent action on the first formed primary condensation products being led through, whereby besides obtaining perfectly colorless resin-like condensation products, a separation is effected from the initial materials not entering into the reaction.

G. P. 219,570/08 Sarason. Production of condensation products of formalde-

hyde and phenols by acting with sulphur dioxide on a mixture of formaldehyde and isolated phenols. The reaction proceeds more quietly than with hydrochloric and sulphuric acids; the reaction products are considerably clearer and readily soluble in caustic alkalies and most of the volatile solvents.

U. S. 965,823/10 Lebach. Accelerating the hardening of condensation products of phenols and aldehydes, with or without a filler, by heating until a uniform viscous mass is obtained, adding an accelerator, as sulphuric acid and glycerol, potassium bisulphite or benzol chloride, bringing the mass into the desired form and maintaining at a temperature below 100 deg. (preferably 60–85) until sufficiently hardened (½–2 hrs.).

Fr. 390,637 07 Produits Chimiques De Grossy. Production of resinous products as substitutes for the natural resins by heating a mixture of glycerol 200, formaldehyde 200, and hydrochloric acid of 21–22 deg. Be. 30–40 parts to boiling for 1–2 hrs., then adding, after cooling to 80 deg., phenol 200. The oil which forms is separated, washed with boiling water, then heated to 150 deg. until upon cooling the resin is hard and brilliant.

Fr. 392,978 07 Produits Chimiques De Grossy. Making products analogous to the natural resins by reacting with aldehydes on phenols in the presence of catalyzers and a moderating agent such as benzol, etc., e.g., phenol 500 kgs., formaldehyde 400 kgs., 50–60 deg. Be. hydrochloric acid, 400 kgs. and benzol 200 kgs. are mixed and heated, removing external heat when the reaction has commenced.

Fr. 392,395 07 Helm. Substitutes for resins and gums are formed by the condensation of phenol 100, 40% formaldehyde 150 parts, with aniline 95 parts, heated together.

G. P. 222,543/08 Knoll & Co. Addition to 214,194/08. Hastening the hardening of condensation products of phenols and aldehydes, by diluting the acids employed with such substances as are miscible with the condensation products, such as ethyl alcohol, glycerol, etc.

G. P. 222,512/08 Berend. Making condensation products by heating the fatty acid salts or resinates of primary aromatic amines or their nucleus substitution products with formaldehyde solution or a polymerized formaldehyde. The resulting anhydroformaldehyde compounds are used as substitutes for camphor and solid solvents for substances such as nitrocellulose in making lacs, varnishes, and the like.

U. S. 982,230/11 Baekeland. Protecting metallic pipes or other objects from chemicals, etc., by coating with a partial condensation product of formaldehyde and phenols mixed with a filler, as asbestos, flint, sand, emery, graphite, clay, cornish stone or iron oxide and hardening the layer by heating.

G. P. 226,887 09 Baekeland. An antifriction material consists of the insoluble and infusible condensation product of phenols and formaldehyde, and heat conductors, such as metal or graphite.

G. P. 228,639 07 Baekeland. In the production of insoluble infusible condensation products from phenols and formaldehyde, applicable as plastic masses, the phenols are heated with more formaldehyde or with more condensation salt or with more of both than is necessary to form the resin-like condensation products soluble in organic solvents. Among the condensation agents specified are neutral or alkaline salts such as potassium chromate, sulphite of ammonium and sodium, and sodium thiosulphate, phosphate, bicarbonate, carbonate and acetate, potassium carbonate or ammonium carbonate. The insoluble condensation products are applicable for decorative and electrical purposes, e.g., for the button industry.

G. P. 233,329 09 Linger. In making condensation products of wood tar and formaldehyde, substances of alkaline reaction such as soda lye or potash lye are employed as condensing agents. Upon gentle heating a vigorous reaction takes place with much fuming and the thin fluid changes into a viscous mass which

solidifies on cooling. After the reaction is concluded the product is diluted with a corresponding amount of water and poured into dilute acid, whereupon the reaction product separates in thin flocks which yield upon drying a porous light brown powder.

G. P. 233,395/10 Baekeland. In making colorless or very light colored insoluble condensation products from phenols and aldehydes, suitable extraction agents, such as ether, are used to remove the color-forming constituent of the readily condensable intermediate products, before the hardening.

G. P. 233,803/08 Baekelite Ges. Making condensation products by subjecting a mixture of phenols and formaldehyde or the intermediate products of their reaction to the united action of heat and pressure until the resulting product is hard, infusible, and insoluble. Filling material may be added before or during the reaction.

B. P. 28,155/10 Baekelite Ges. Making a plastic body by mixing in the presence of water, fibrous matter, or a pulp containing fibrous matter, with chemical agents capable of transformation by heat into an insoluble and infusible condensation product of a phenol and formaldehyde and forming the mass into a plastic body.

B. P. 21,401/10 Pollak. Making insoluble opaque white condensation products from phenols and formaldehyde, by treating a substance of the phenolic series with formaldehyde in the presence of a small quantity of acid (not to exceed 1.5% of the insoluble final product), and coagulating and hardening the intermediate product by the action of heat.

U. S. 1,018,385/11 Baekeland. Varnish containing a condensation product of phenols and formaldehyde.

U. S. 1,019,406/12 Baekeland. A composite cardboard is made with intermediate layers of phenol-formaldehyde condensation product.

U. S. 1,019,407/12 Baekeland. Cementing objects with phenol-formaldehyde condensation product.

U. S. 1,020,593/12 Aylsworth. A condensation product is formed of phenol and formaldehyde combined with hexamethylenetetramine.

U. S. 1,030,594/12 Aylsworth. A solid solution is made of a phenol-formaldehyde condensation product and phthalic acid or anhydride.

B. P. 28,491/10 Kunisch. Ammonia, in the presence of hydrogen sulphide with or without carbon disulphide, is used to condense phenol-formaldehyde. Zinc oxide may be added. The product is finally heated higher than 130 deg. under a pressure of 100–300 atmospheres.

Can. 139,033/12 Baekeland. Making insoluble compounds by the action of a formaldehyde on anhydrides of phenol alcohols.

G. P. 237,743/08 Noa. Making a shellac substitute by cooking together hot phenol and starch treated with dilute nitric acid, the resulting solution being thickened by a further addition of stearin, resin, formaldehyde and mineral acid.

G. P. 237,786/10 Bayer & Co. Mono- and di-chlorohydrin are used as condensing agents in forming phenol-formaldehyde products. The product is heated until a test portion hardens; glass-like, almost colorless substances are obtained which are used as shellac substitute or for making other resin-like bodies.

U. S. 1,027,794/12 Aylsworth. Making hard fusible phenol-resin compounds.

Aust. 8,096/09 Paquie. In making a permanently clear condensation product from phenols and formaldehyde, ammonia is employed as the condensing agent. The intermediate product obtained is heated above 130 deg. under high pressure (over 100 atmospheres).

Fr. 395,657/11 Knoll & Co. First addition of Mar/11. In the preparation of resin-like condensation products from phenols and formaldehyde, the latter is used in excess.

G. P. 237,790/08 Baekeland. In making phenol-formaldehyde condensation products the reaction is carried on until an intermediate product is formed which is insoluble in alcohol or glycerol, softened by phenols or acetone, hardens at the ordinary temperature, and becomes soft and elastic in heat, when the final form is given to the article and it is heated to form the end product.

B. P. 3,496/11 Aylsworth. Infusible resins are produced by heating a methyleneamine compound such as hexamethylenetetramine with a fusible phenol-formaldehyde condensation product. The fusible resins used as parent materials may be produced by the interaction of approximately 3 molecular proportions of phenol with 2 of formaldehyde and may be completely anhydrous and free from uncombined formaldehyde.

B. P. 3,497/11 Aylsworth. A hard insoluble condensation product is formed of phenol or cresol with formaldehyde or its polymers, by mixing an intermediate fusible product with a substance which reacts on heating, such as hexamethylenetetramine or other methyleneamine, formaldehyde or its polymers. It is used for surfaces of sound records, etc.

B. P. 3,498/11 Aylsworth. An infusible phenol-formaldehyde resin is produced by heating a fusible phenol-formaldehye resin, preferably anhydrous, and free from uncombined formaldehyde, with the necessary quantity of formaldehyde.

U. S. 1,029,737/12 Aylsworth. Making a hard fusible compound of phenol and formaldehyde.

B. P. 6,429/11 Knoll Co. Light colored infusible resins are produced by the condensation of phenols and formaldehyde in the proportion of not less than 2 molecules of the latter to 1 of the former, and in the presence of condensing agents such as acids, acid salts, alkalies, neutral and alkaline salts, etc. The total quantity of formaldehyde may be present from the commencement of the reaction, or the excess may be added after fusible resins have been first produced.

B. P. 6,430/11 Knoll Co. Phenol-formaldehyde condensation products are treated with formaldehyde either before or during the acid hardening process, in the former case with introduction of a small quantity of a condensing agent if necessary; colorless or lightly colored resins result. Substances may be employed such as chloromethyl alcohol which are capable of producing formaldehyde and acid.

G. P. 247,181/09 Mauthner. Resin-like products are made by heating cellulose and phenols with mineral acids as condensing agents. The reaction is interrupted at either the liquid or plastic stage, and on further heating there results respectively a plastic or a solid product.

U. S. 1,033,044/12 Aylsworth. Forming molded articles by placing phenol in a mold and treating it with formaldehyde under pressure.

U. S. 1,102,473/12 Chappell. Packing for steampipes, etc., is formed of phenol 100, formaldehyde 60–120 and oleic acid 20-60 condensed with ammonium oleate 1–15 parts at 100–200 deg. for 2–6 hrs. Fillers such as asbestos talc, mica or lead may be added.

U. S. 1,037,719/12 Baekeland. A varnish contains a condensation product of phenols and formaldehyde, a solvent therefore, acetone and a hydrocarbon.

U. S. 1,038,475/12 Baekeland. Transforming phenol alcohols or their anhydrides into hard coherent infusible substances by treatment with formaldehyde.

U. S. 1,039,858/12 Weindel. Producing condensation products of phenol with formaldehyde in the presence of monochlorohydrin.

U. S. 1,039,859/12 Weindel. Producing phenol-aldehyde condensation products in the presence of a hydrosulphite as a restrainer of the reaction.

U. S. 1,040,850/12 Berene. Making a condensation product of casein, phenol and formaldehyde.

G. P. 250,281/10 Diesser. Elasticity is imparted to the brittle product obtained

by evaporating a solution of albumen in formic acid by adding to this residue a phenol-formaldehyde condensation product. Transparent, elastic skins are obtained, insoluble in water.

PLASTIC COMPOSITIONS

U. S. P. 1,360,130/20 Mayer and Wiggin. A plastic comprising approximately 1200 lbs. plaster of Paris, 200 lbs. of talc, 6 lbs. of cold-water paste, 1 lb. of gum karaya, 4 lbs. of cold-water glue.

U. S. P. 1,361,759/20 Ey. A composition of matter comprising the following ingredients: 3 parts of flour, 4½ parts of glue, 15 parts of asbestos cement, 60 parts of whiting, and mixed with 23½ parts of water to form a plastic substance appropriate to be packed in molds or dies.

U. S. P. 1,364,004/20 Stowell. A plastic composition consisting of coal ashes, approximately 50 parts, sodium silicate, approximately 12 parts, ground talc, approximately 10 parts, and combined with Portland cement.

U. S. P. 1,365,607/21 Swett. A composition of matter comprising rosin, and a resin and a phenol which are both alcohol-soluble, all compounded together.

U. S. P. 1,365,882/21 Barton and Gardner. A hard, dense, polishable plastic consisting principally of a homogeneous magma formed and indurated by aid of inter-action and resulting transformation of its from-cellulose-derived and other oxygen-containing organic constituents, the step which consists in incorporating with said constituents, prior to their said transformation, particles of alkaline earth sulphate having thereto adherent particles of amorphous titanic oxid.

Swiss P. 1,367,886/21 Mooser-Schiess. The process for making plastic masses which consists in heating yeast with esters of the organic acids with polyvalent alcohols.

U. S. P. 1,368,949/21 Loeffelhardt. The method of producing a stone-like composition, wherein different batches of calcined magnesite, a filler, and magnesium chlorid are prepared separately; introducing into a given patch or batches a coloring agent to produce contrasts; removing the free air content from the batches, and the fragments assorting; and then making a cement of substantially the same substances and mixing therewith the assorted particles and applying to form a layer or other body.

U. S. P. 1,370,637/21 Erwin. A process of producing a plastic composition consisting in colloidally suspending a mixture of colloidal mineral dust, sodium chlorid and sodium sulphate and injecting sulphur into preheated bitumen in a vat subjected to heat and suction and combining said ingredients and their derivatives with each other therein, then mixing vegetable and mineral particles of relatively larger sizes, in the absence of dust, with said compound in sufficient quantity of the latter to merely impregnate completely, to coat and to bind together the mass when compacted to final shape; then agitating the mass in a vat under the influence of sufficient heat and suction to completely dehydrate the same and to fix its temperature at approximately 250° F., then removing the mass from the vat and compacting the same to shape.

U. S. P. 1,372,467/21 Willis. A method of forming a plastic composition consisting in heating a finely divided filler, adding thereto a mineral asphaltic binder heated to approximately 300° F. and a salt of aluminum having tempering properties.

U. S. P. 1,376,523/21 Formby. A process of producing a plastic composition which consists in adding water and lime to calcium and magnesium oxychlorid; boiling the mixture thus produced and letting it set; and mixing a substantially equal volume of Keene's cement with said mixture.

U. S. P. 1,379,052/21 Sharpneck. A method of forming plastic compositions which consists in mixing a finely divided filler and Portland cement together and

heating to a temperature of 300°-350° F., also heating mineral asphaltum to a temperature of 300°-350° F. adding pulverized borax thereto, then mixing the asphaltum with the filler while the asphaltum is in a high state of effervescence and while the mass is maintained at a temperature of 300°-350° F.

U. S. P. 1,379,590/21 Clapp. A process which comprises mixing dry Portland cement and molten asphalt, incorporating in such mixture an aqueous paste of Portland cement and clay, and finally distributing finely divided sawdust and cotton fiber throughout the product.

U. S. P. 1,384,037/21 Armstrong. A plaster composition comprising approximately 85 lbs. of calcined gypsum, mixed dry with approximately 15 lbs. of finely divided peat or peat moss, the combined 100 lbs. of dry mixture being mixed with water in sufficient amount to make it workable.

U. S. P. 1,388,472/21 Lindsay. A process of combining a soluble acetyl cellulose and borneol, which consists in dissolving said substances in a solvent comprising a mixture of fused oil and a chlorinated hydrocarbon alcohol solvent.

U. S. P. 1,390,435/21 Gerlach and Lihme. A process of preparing material for molding purposes which consists in reducing the molding material to a plastic condition with sulphite liquor from sulphite pulp manufacture, and including a quantity of non-adhesive material to prevent adhesion to the molds.

U. S. P. 1,393,814/21 Noll. A composition for making plaster containing substantially the following proportions by weight: Dry slaked lime 20 parts; dry yellow clay 15 parts; dry silica sand 40 parts; dry blast furnace slag 25 parts.

F. P. 1,394,746/21 Leroy and Claireaux. A process of manufacturing a plastic product comprising: melting gelatin or glue, mixing it during fusion, with glycerin or complementary product, casting the mass in plates or blocks which are cut in small pieces, drying these pieces, transforming the mass in plates, dipping it in formol and drying it thoroughly.

U. S. P. 1,398,613/21 Watson. A method of preparing plastic pavement consisting in mixing refuse sponge from gas purifiers, sand and gravel, oil and water gas tar, lamp black, thoroughly agitating the same, heating, dewatering, then allowing it to cool and reheating to about 200° C. for final use.

U. S. P. 1,402,969/22 Santen. A composition comprising pyroxylin pulp, ether denatured ethyl alcohol solution of camphor, rosin and naphthalene, and polymerized tung oil, reduced to plastic condition, and adapted to harden by evaporation of the ether denatured ethyl alcohol of the solution.

U. S. P. 1,409,088/22 Erwin. A process of producing a plastic composition consisting in colloidally suspending a mixture of mineral dust, sodium chlorid, sodium sulphate, and lime with, and injecting sulphur into, preheated bitumen in a vat subjected to suction and to sufficient heat to combine the ingredients and their derivatives, then mixing various sizes of mineral aggregate in the absence of dust with said composition in sufficient quantity of the latter to fill the interstices, to partially impregnate and to coat and bind together the mineral aggregate under pressure, then agitating the mass in a vat under the influence of suction and sufficient heat to fix its temperature at approximately 250° F., uniformly, then removing the mass from the vat and compacting the same to shape.

U. S. P. 1,409,939/22 Formby. A plastic composition consisting of calcium and magnesium oxychlorides that have been heated in a mixture of lime and water, and the compound thus produced mixed with substantially an equal volume of plaster of Paris.

U. S. P. 1,416,684/22 Brower and Werle. A composition for the production of plaster consisting of Brixment cement, Portland cement, lime, sand, hair fiber, and pulverized alum substantially in the proportions as follows: 1090 parts Brixment cement, 535 parts Portland cement, 185 parts lime, 185 parts sand, 5 parts hair fiber, and ½ part pulverized alum.

BOOK II

THE USE OF PLASTICS FOR MOLDED ELECTRICAL INSULATION

INTRODUCTION

If there is any one material thing which, more than any other, has put a characteristic stamp upon this age in which we live, it is coal. There have been other civilizations which have approached or perhaps even exceeded ours in their achievements in art, philosophy, and in certain branches of pure science. We still bow in admiration before the geometry of Euclid, an admiration which has been enhanced rather than diminished through the scrutinies of the most modern mathematicians of the basic foundations upon which the structure of their art rests.

But if, in abstract science, the ancients achieved as much as we (allowing for their lesser heritage from predecessors), it is in the technical applications that the present age stands immeasurably in advance of any period of which we have record. And these technical applications in the past (though they may not in the future be thus dependent), have rested upon one indispensable feature—*Coal.* Boundless is the extent to which industrial power, derived from coal, operates in our modern social organization.

Yet, strangely enough, this very use of coal as commonly practiced for the production of power, stands as a flagrant violation of one of the fundamental, most elementary principles of industrial economics. This obvious principle is that in the transportation of a commodity from its source to the consumer, the first step should always be to *concentrate,* as far as possible, the value of the commodity; that is, to rid it of all unnecessary encumbrances, which act as mere ballast in transport. For example, wherever possible, the metal is extracted from the ore near the mine, and the free metal shipped to its place of consumption, or where this cannot be done, the portions of ore containing a higher percentage of metal are separated from the lower grade material and the concentrated ore sent on its way.

But in the case of coal, the thing of value is not material at all. Coal in industrial use for power production is merely the vehicle of energy. When a ton of coal is shipped from the mine to the factory, not only a portion, but the whole of that ton of matter is mere ballast. The *substance* of the coal has no value whatever to the purchaser and is allowed to go to waste up the stack, as carbon dioxide, and into the ash pit as cinders. Yet the consumer must pay freight charges from the mine to his premises upon just such waste substance. In reality he is paying freight not upon coal, but upon the carbon, silica, etc., in his cinders, and in the flue gases. The economist abhors such an intolerable waste when there is a means of preventing it. And such means is given us in the form of electrical energy.

For, electricity, as it were, is disembodied energy, emancipated from the bonds of ordinary matter, and capable of traveling from place to place independently of any moving vehicle. However, while electricity requires no moving vehicle to be transported from place to place, it does of course demand channels and means to guide it in the particular course in which we desire it to travel, which we call electric conductors (telephone and telegraph lines, power leads, etc.) and electrical insulators. It would be fruitless to discuss which of these two is of more importance since both are wholly indispensable.

There is no hard and fast line that can be drawn to divide the two, but in practice some few substances stand out as particularly good conductors, while at the other extreme stand a number of materials more or less perfectly adapted to function as insulators. A general rule can be stated regarding the conductors, namely, that all metals are good conductors, at least in comparison with non-metallic substances. No such simple rule can be given for insulators. It is a noteworthy fact, however, that transparent solids, in accordance with the electro-magnetic theory of light, are insulators; and this, in point of fact, is true, as for example in the case of glass. If its surface is clean and dry it is a good insulator. The rule does not apply to liquids which conduct electrolytically; nor is the converse true, that an opaque solid is necessarily a conductor. There are many excellent insulators of modern manufacture which are opaque and black or dark in color.

The selection of materials for good insulators must be made in a purely empirical way. Certain substances have in the past proven to possess in greater or lesser degree the requisite electrical, mechanical, and chemical properties which together with a consideration of the first cost, determine the choice for any particular application. An ideal insulator fulfilling all requirements in all uses, is not and may never be known.

We shall here consider some of the principal substances or compositions of plastic characters which have found extensive use in the manufacture of Molded Insulation.

CHAPTER I

HISTORY OF MOLDED INSULATION

MOLDED INSULATION TWENTY YEARS AGO

Twenty years ago the molded insulating material most extensively used was porcelain. It was practically the only fire, heat, and waterproof material known at the time. When properly made, its high dielectric strength or resistance to the passage of electric current and puncture by electric discharge, the waterproof qualities, and the low cost made it indispensable for a great many uses. Because of its brittleness, however, it proved unsuitable for many purposes, in which instances electrical engineers and constructors employed a variety of other insulating substances such as vulcanized fiber, wood impregnated with oil, hard rubber compounds, asbestos-rubber compositions, low melting shellac and gum products, mica, etc. For purposes where mechanical strength was a prime factor hard rubber was much used as an electrical insulator both in molded and sheet form, either as such or as a binder in materials having asbestos or other mineral substances as fillers. These so-called vulcanized asbestos materials, composed of asbestos fiber with rubber as a binder, were molded into the required shapes and then vulcanized. They were excellent in every respect with the exception of cost and ability to withstand any considerable degree of heat.

These hard rubber products constituted practically the best molded materials produced up to that time, but the constantly increasing price of rubber made the cost of producing articles therefrom prohibitive for many purposes, and led to many substitutes, some of which came into extensive use, especially the so-called "shellac compounds," based principally on the use of shellac, asphalt, rosin, and other natural and synthetic gums as binders for asbestos, woodpulp, or other fillers.

The shellac compositions were molded in heated dies and then cooled, before being removed therefrom as a finished product. This method of manufacture is much cheaper and simpler than the somewhat lengthy process of vulcanization, so necessary when rubber is employed.

Numerous attempts have been made during the last ten or twenty years to utilize alkaline silicates as binders for asbestos and other fillers. They made good binders but on account of their inability to resist the softening influence of moisture, various processes were developed to render them insoluble. These depend on the use of lime compounds, aluminates, etc., and while it has been found possible to convert the silicates into a somewhat insoluble form, other products of reaction are

always present, which are just as readily affected by moisture, or otherwise objectionable. Further, in many cases the silicate compounds formed are found to be acted upon by some of the other components so that disintegration eventually occurs. This class of materials has therefore practically disappeared for molding purposes in the insulation field.

A material of more promise employed, is hydraulic cement and water mixed with asbestos fiber. It was formed into thin sheets on a machine similar to that used for paper-making and as many of these sheets were built up as were necessary to obtain the desired thickness. These sheets were cut to size and held under pressure until the hydraulic cement had undergone preliminary and initial set. Such a material, while somewhat hygroscopic, is very stable and improves rather than deteriorates with age and climatic exposure. These and other characteristics have stimulated experiments with this type of substances, and great progress has been made in the manufacture of molded insulation therefrom. The greatest drawback to the early products obtained by this process was that it was not possible to mold them in any way but very simple forms, mostly all designs being flat pieces. Reference to this product will be made later under cold molded inorganic materials, Class D.

A great number of patents have been issued and much literature has been published relating to Hot Molded Phenol Formaldehyde Products obtained by condensation reactions of phenol (carbolic acid) and aldehydes or their derivatives. Such resin-like substances were intended as a substitute for the natural resinous binders in the so-called shellac compositions. The products were first only produced in an experimental way, with indifferent commercial success and were little heard of for a number of years.

The desirability of a material which, when properly made, would have the easy molding properties of the shellac materials, and in addition possess the great heat-resisting qualities and dielectric strength which these new synthetic products promised, promoted their rapid development so that to-day their manufacture has grown into an important industry. The materials known in the trade as: Bakelite, Condensite, and Redmanol, belong to this class and are unsurpassed for certain purposes.

Another product of which great success was expected was a composition of ox blood and wood pulp molded in hot dies in a manner similar to the shellac compounds. This material was obtained by treating the blood for its fibrine. It was then dried and powdered and mixed with the filling materials. The mass was then subjected to hydraulic pressure in hot closed dies. The binding qualities of the fibrine and consequently the tensile strength of the product was sometimes increased by the addition of glutinous or resinous substances. One process employed wood pulp having a large resin content, which, under heat, united with the fibrine to cement the mass more thoroughly.

Perfectly molded articles of this type possessing higher heat-resisting properties than the shellac materials were made and used quite

considerably for telephone receivers and similar work; but owing to the fact that this product is not as readily molded or chemically as stable as shellac or rubber, its use has practically been abandoned.

An entirely different material which has found more extensive use in domestic purposes than in the electrical arts is formed of casein, chemically treated to convert it into a hard, tough, substance (galalith). This material can be easily molded and worked upon with tools but on account of its inability to absolutely withstand moisture, its usefulness for electrical purposes is limited.

An attempt was made in England to manufacture a product employing sulphur as a binder for organic and inorganic materials, but after a few years of unsuccessful operation the company failed. This process was foredoomed to failure at the start, for it has long been known that metallic parts embedded in hard rubber containing an excess of sulphur are energetically attacked by the acids resulting from oxidation of the sulphur. For this and other reasons, the material lasted only until a superior successor appeared.

Several attempts have also been made to use waste from the manufacture of horn and hoof products by dissolving or agglomerating it and afterward welding under heat and pressure. These were a total failure. The idea originated from the use of such materials in the manufacture of buttons, hair ornaments, and the like. Several factories were simultaneously started, both in this country and in Europe, to market the products. Samples accompanied by glowing prospectuses appeared; but the samples, after a few months' exposure to the atmosphere, underwent such physical and chemical changes as to demonstrate their unfitness for electrical purposes.

The process of manufacture was to reduce the cleaned raw materials to a powder and compress this powder in hot dies. If the material had then become sufficiently plastic to mold properly, and if it had coalesced under heat and pressure, it might have had a happier history, but unfortunately, it was found necessary to mix with it such reagents as hydrochloric and sulphuric acids, various alkalies, etc., as an attempt to dissolve, agglomerate, or decompose the powder and render it plastic. The nature of the chemicals employed and their imperfect combination with the horny substance resulted in very unstable products.

Papier Maché formed into various shapes has been widely used both here and abroad. Such products were made by sticking together sheets of specially prepared stiff paper with glutinous substances, and placing the prepared sheets in wood or metal forms to produce the desired shapes. These were placed in ovens until the whole mass became dry and hard. The pieces were then coated with varnish, made of asphalt and resin dissolved in linseed oil, or other suitable solvents, and again placed in the ovens so that the insulating varnishes were made to penetrate the surface layers of the paper. This process was repeated until the paper became covered with a hard, tough, waterproof, insulating surface. As the varnishes employed were the principal insulating elements, it is obvious that the quality of the product depended upon them.

Such materials are well adapted to the manufacture of bobbins, large switch box covers having thin walls, and similar parts difficult to mold of plastic materials and they are still used to a considerable extent. The articles produced are flexible, very tough, and fairly good insulators.

Another form of material which has practically disappeared, employed cabinet-maker's glue as a binder for vegetable or mineral fillers. The glue was mixed with the powdered fillers and molded in heated dies or rolled in sheet form. The sheets were cut to the required size and molded in a heated condition. Products therefrom were generally treated with formaldehyde, chromates, or other chemical agents to render the glue waterproof and chemically stable.

Attempts were made to produce a molded insulating material by treating cellulose and celluloid in a number of different ways to reduce their inflammability, but while these materials achieved success in other industries, they were of no value as electrical insulators.

Numerous attempts have been made to use paraffin and vegetable waxes as binders, but these materials proved to be of short-lived popularity owing to their low melting points.

Efforts have been exerted to use the waste of slate and marble works, by reducing it to a fine powder, mixing it with the proper binders, and molding under heat and pressure. The resulting products resembled natural slate and marble, but while they are still made to some extent, their use is diminishing.

Another class of materials employing a vegetable gluten for a binding medium was composed of starch or dextrines, and vegetable or mineral fibers. After being molded and dried, the parts were impregnated with mineral or vegetable waxes. Fairly stable materials were thus obtained, but to-day these products are extant only in memory.

A material was made of the powdered waste of soapstone by mixing it with suitable fluxes, and firing the molded parts somewhat after the manner of porcelain. In this country, the molding of such soapstone products has not been developed to any considerable degree, but the author predicts that within the next ten years *molded* soapstone products will be a potent factor in the industry of ceramic insulators.

Peat has attracted considerable attention for molded insulation experiments in view of its low cost, its wide distribution and its fibrous texture. Peat materials made with asphaltic or resinous binders were in practical use for some time, but have almost entirely disappeared owing to their poor heat-resisting qualities.

Seaweed, treated by various chemical means, has been utilized in an experimental way as a binder with asbestos or other filler, but no commercial molding mixtures or molded products have as yet been obtained from seaweed derivatives.

MOLDED INSULATION OF TODAY

The following chapters will deal with molded insulating materials employed to-day, including such of the above mentioned early ones as are still in practical use, and eliminating those which have been abandoned.

Such molded insulating materials may be broadly grouped into the following classes:

Class A—*Hot Molded Phenol-Formaldehyde Products*
Molded products obtained by mixing synthetic organic binders with organic or inorganic fillers, molding such mixtures in heated molds, and removing therefrom the shaped articles in finished form after cooling. Bakelite, Condensite, and Redmanol, are the best known representative products of this class.

Class B—*Cold Molded Organic Insulation*
Molded materials obtained by mixing solutions of resinous, asphaltic or synthetic binders with organic or inorganic fillers, molding such mixtures in cold or hot molds, removing the pressed parts from the dies without cooling operation and hardening the molded products afterwards by means of heat. This class of materials is best known to-day as "Cold Molded Composition," or under such trade names as Aico, Gumon, Thermoplax, etc.

Class C—*Hot Molded Organic Compositions (Shellac Compositions)*
Molded materials obtained by mixing shellac, resins, asphalts, with organic or inorganic binders, usually under heat, and molding the mixture in heated molds, removing the shaped article therefrom after cooling in finished form. This class of material is best known in the electrical and other industries as "Composition" or "Low Heat Resisting Composition." Trade names for such products are Insulate, Duranoid, Shawlac, Composite, Electrose, Ambroin, Eburin, Adit, Ebonitine, Chrystalate, etc.

Class D—*Inorganic Cold Molded Materials*
Made by mixing inorganic binders such as Portland cement, silica, calcium, or magnesium compounds with inorganic fillers by means of water and solidifying the pressed mass after removal from the mold. Such products are known as Asbestos Lumber, Asbestos Wood, Electrobestos, Ebony Wood, Aico No. 5, Hemit, Pyroplax, Eternit, etc.

Class E—*Ceramics (Porcelain, Lava)*
Ceramics, known generally under the name of "Porcelain," made from a mixture of China clay, silica, and water, molded and heated to a fusing point after removal from the dies.

Class F—*Rubber Compounds*
Mixtures of rubber or gutta-percha, mixed with inorganic fillers and vulcanized by well known processes with sulphur. Such compositions are known as Hard Rubber, Vulcasbestos, Ebonite, Stabilit, etc.

Class G—*Organic Plastics*
Materials made from organic materials chemically treated to render them plastic, and molded into the desired forms. This class embraces a wide range, the principal products being casein preparations and cellulose compounds.

Class H—*Laminated Insulations*
The molding of this class is practically limited to the production of sheets, rods, and tubes, or shapes of simple form.

The qualities of these different products vary widely and there is no one insulating material made to-day which fulfills all the requirements demanded by the various electrical applications.

Some manufacturers claim their products to be suited to all applications, but such a claim is necessarily unsound. For instance, while the materials of Class E are fireproof, waterproof, and inert under all climatic influences, their use is limited to such purposes as do not require accuracy of dimensions or great mechanical strength; and while materials of other classes can be molded more or less to true sizes and are mechanically strong, they are not as proof against climatic conditions.

Therefore, the electrical engineer has to use his own judgment as to the insulator he should choose for his particular needs, and fortunately he has at his disposal a variety of materials from which to make proper selection.

The manufacture of molded insulation involves well defined steps such as the selection and preparing of raw materials, mixing, molding, and finishing; and particularly, it requires long experience to produce results satisfactory to the users of molded parts.

A proper selection of raw materials is, of course, the first step, but manipulation of the material through all its stages of manufacture requires an intimate knowledge of seemingly unimportant detail. The amount of heat employed, the pressure used, and the speed with which it is applied in the molding process, has a very great influence on the character of the finished product. Two pieces having the same ingredients and subjected apparently to the same treatment, while they may be alike in appearance, may vary greatly in their behavior in use. Too little pressure, too great pressure, or pressure improperly applied, will produce an article of poor mechanical strength, and of low electrical resistance; and by seemingly slight departure from the normal on through the various steps of manufacture, serious variations or defects in the finished products may be caused.

Each of the several steps in the production of molded insulation represents by itself a separate manufacturing problem, and the most rational procedure would seem to be to carry out certain of these steps as entirely separate industrial operations. This is what has actually been made the standard practice in the manufacture of insulators of Class A (Bakelite group). Here the production of the plastic substance is essentially a problem of chemistry, which is best conducted under the guidance of skilled chemists; as the present industry has developed, it has been found advantageous to carry this on as a separate industry, in the hands of specialized concerns. Three such firms are to-day supplying the market. On the other hand, the molding of the material is more particularly a problem in industrial mechanics, and this, in turn, is now carried out in separate establishments. This splitting up of the two functions—the preparation of the molding material, and the molding itself—is a policy which has not only been found most advantageous in the Class A (Bakelite) industry, but which commends itself as the proper course to be adopted in the future in other branches of the

manufacture of molded plastics. The author is of the opinion that the high development of the Bakelite industry to-day is in no small measure due to this policy of separate organizations for the preparation and for the molding of the plastic, and that the phenol-formaldehyde products would not have attained their present high standard had the usual procedure been adopted of carrying out both steps jointly in single establishments. The splitting up of the industry into two separate branches enables the workers in each branch to give their full attention to the problems peculiar to their branch; and, as already indicated, these problems are essentially dissimilar in character, chiefly chemical in the one case, chiefly mechanical in the other, and thus call for specialized technical forces in each instance.

The makers of materials of Classes B and C maintain that their own control of their mixing compounds is vital to their particular molding methods. The author has given this subject a great deal of thought and he is inclined to think that the manufacturers of molded insulation of Classes B and C may change the views hitherto held by them, and may follow the example of the manufacturers of Class A materials. It seems to the author that only in this way can well-defined progress and improvement be looked for in the production and adaptability of materials of Classes B and C.

Before going into further detail of these various classes, it is well to discuss briefly the raw materials employed, explaining their derivation, characteristics, and properties which render them valuable in the manufacture of molded insulation.

CHAPTER II

RAW MATERIALS

Asbestos derives its name from the Greek language and means "incombustible" or "unconsumable" and, while the every-day use of it in our industrial and home life is not yet 50 years old, we can trace the sporadic application of it nearly to the dawn of history, as the earliest reference to it is found in Pausanias, who mentions that the wick of the eternal lamp in the temple of Pallas Athene was made of "stone flax." The old Romans used blankets made from "unburnable stone fiber" round the corpses of their heroes on the funeral pyre, in order to separate their ashes for the purpose of worship from those of the burned wood, and Charlemagne astounded his courtiers by cleansing his table cloth in throwing it into the fire and withdrawing it intact and clean.

It is difficult for the layman to understand how a substance can be fibrous and yet be a stone but, if we remember how minerals, if certain ideal conditions prevail, shape themselves into crystals in nature, this phenomenon is easily understood. Salt will crystallize in cubes, quartz in hexagonal columns, mica in sheets, other minerals in the form of needles and, if these needle crystals can be separated without breaking and are flexible, they are fibers, or bundles of fibers, and it is just the flexibility of the needle crystallization of asbestos which gives it its commercial importance.

Chemically speaking, asbestos is composed mainly of silica and magnesia, two of the most common constituents of our rocks but, in order to form asbestos, it is not only necessary that these two ingredients come together in just the right proportions, but they must also contain the correct percentages of other ingredients, such as lime, iron, alumina and water and, moreover, physical conditions, such as temperature, pressure, etc., must have been of such a character and duration as to allow the proper forming of the fibrous crystallization.

Therefore, we have but comparatively few districts of a limited area in the earth crust where asbestos of economic value is found. The chief source of supply has always been, and will probably always be, a small group of undulating hills in the Province of Quebec, about 70 miles south of the City of Quebec in Canada. In the United States we have a much larger area of asbestos-bearing mountains, namely in the State of Arizona on the banks of the Salt River of Roosevelt Dam fame and in the surrounding territory, but the canyon-like character of the country, its inaccessibility and the resulting transportation difficulties have retarded the development there considerably. South Africa,

i.e., Rhodesia, Cape Colony and Transvaal, have during recent years come to the fore as producers of asbestos, and the Ural Mountains of Russia, near Ekaterinburg, also contain fairly large and promising deposits.

Experts can detect at a glance from which country a piece of asbestos comes, as each district has its own distinctive peculiarities and also its different chemical composition.

Trade and industries, as a rule, distinguish between two main varieties of asbestos, chrysotile and amphibole respectively. While theoretically amphibole will stand a higher degree of heat before disintegration, it is technically of much less importance, as the fibers are weak and brittle, and it is the great flexibility and tensile strength of the fibers of the chrysotile variety which gives this asbestos its commercial importance.

The Canadian chrysotile occurs in serpentine rock which carries a large amount of chromic iron in finely disseminated crystalline form and special care must be taken to eliminate the particles of chromic iron from the asbestos fibers if they are to be used for electrical insulation. Nature has been more considerate in creating the Arizona deposits of asbestos, as serpentine is replaced by limestone, and there is no trace of any free iron either in the Arizona limestone, or the asbestos it bears.

The following table of analyses of asbestos from different locations will give food for thought to those interested in the intricacies of the subject:

Chemical Constituents	*Canadian Chrysotile*	*Arizona Chrysotile*	*Amphibole Fiber*
Silica (SiO_2)	39.60	41.71	61.82
Magnesia (MgO)	40.15	41.99	23.98
Alumina (Al_2O_3)	2.87	2.80	1.12
Ferrous Oxide (Fe_2O_3)	2.90	.50	6.35
Lime (CaO)	—	.09	1.63
Water (H_2O)	14.48	12.91	5.45
	100.00	100.00	100.35

Only asbestos of the chrysotile variety is of importance in the manufacture of Molded Insulation, as the fibers which are to be used, while short, must have the necessary mechanical strength of resistance and flexibility, without which the binders in Molded Insulation would fail. These asbestos fibers are intimately mixed with organic binders which impregnate and coat the individual asbestos fibers and the mass is then hydraulically pressed into the desired shapes and forms, resulting in a product which has all the good qualities of asbestos, resisting heat as well as electricity and, therefore, being "incombustible and unconsumable" and yet improving upon the raw material nature has given us, by the proper selection and skillful application of organic binders which make the finished article also moisture proof and inert to the influence of most liquids and fluids, except acids, a property which asbestos in itself does not possess, as it is slightly hygroscopic.

A word of caution may not be amiss against the use of Molded

Insulation material containing asbestos, where it comes in contact with acids or strong alkalies. While it is true that by intimate mixing asbestos fiber with organic binders, the former may be impregnated or coated, rendering the asbestos fiber itself temporarily acid-resisting, it will inevitably succumb to the action of the acid in the course of time.

It, therefore, goes without saying that in the successful manufacture of Molded Insulation not only the right kind of asbestos from the best available sources of supply must be selected by experts of long experience, but it is also necessary to prepare this asbestos in such a way that it will most readily absorb and amalgamate with the organic binders, the choice and proper manipulation of which is in itself the study of a lifetime. Also, the exigencies of our modern industrial requirements demand the minutest care and surveillance during every step of the manufacture, from the selection of the raw material to the polishing and smoothing of the surface of the finished article. New problems of a different nature are encountered in a factory making Molded Insulation every day, and, in order to attain success, "it is necessary to strive to seek to find, and not to yield."

Clay. Clays are of importance in insulation manufacture, being the principal raw materials of porcelain. For this purpose clay must possess fineness of grain, freedom from flint and other impurities, and in addition to silica and alumina as its essential ingredients it must contain what are known as fluxes. The fluxes commonly employed are lime, magnesia, soda and potash. They occur in clays in varying amounts. The function of the fluxes is to unite with the silica and alumina, forming fusible bodies, which enable the pieces to be vitrified when fired. Many clays are quite deficient in these fluxes and to these, therefore, fluxes containing the necessary ingredients are added. Other materials are added to decrease shrinkage during the firing process, the most common of these being sand of a pure grade.

One of the uses of clay in connection with electrical insulation, which, however, is of lesser importance, is its employment as a raw material in the manufacture of Portland cement. In certain sections of the world vast quantities of clay are so used, the clay supplying the silica, iron oxide and alumina, while limestone supplies the necessary lime ingredients. For this purpose the purity and physical structure of the clay are of minor importance, the essential being that the silica content be from two to three times the content of combined iron oxide and alumina.

Mica. Mica is a mineral of peculiar characteristic laminated form and is of prime importance in the electrical arts, because it may almost be called a perfect insulator in its crude or natural state.

It is mined chiefly in Canada, the United States, India, and Siberia, and is found in sheets or laminated blocks which readily split up into thin sheets. Small mica crystals two or three millimeters square have been artificially produced by slowly cooling a melt of suitable ingredients.

In addition to its high dielectric strength mica possesses great heat-

resisting qualities and is chemically inert under ordinary conditions. It is waterproof and acidproof; these properties combined with its great flexibility make it an ideal insulating material for many purposes.

Chemically it is a silicate of aluminum and magnesium combined with smaller percentages of potassium or sodium and iron.

An analysis of a kind of mica used for electrical insulation shows its composition to be approximately as follows:

Alumina (Al_2O_3)	21
Silica (SiO_2)	41
Potash (K_2O)	8
Iron Oxide (FeO)	6
Manganese Oxide (MnO)	2
Magnesium Oxide (MgO)	19
Water and Other Volatile Matter	3

Oil somewhat reduces the insulating value of mica. While in its natural state it is an excellent insulator, its tendency to split under stress or manipulation renders it necessary in most cases to subject it to some reinforcing treatment. This is done by separating the mica into sheets as thin as possible and cementing them together with resinous binders, under heat; in this manner sheets of any reasonable dimensions can be obtained, the size of which is not restricted by that of the natural pieces.

Such built-up mica can be molded into simple shapes or uninterrupted flat or curved surfaces. In this form it has found extensive application for electrical insulation.

Finely reduced mica, the pulverized refuse of the foregoing and other mica manufacturing processes, is also used in the manufacture of molded electrical insulation. As a filler, in such compositions it is in some instances superior and in others inferior to asbestos fiber. Owing to its poor adhesive qualities and its chemical and physical inertness, mica adds no strength to mixtures but rather weakens them. Its use as a filler, therefore, is practically confined to that type of insulators in which great dielectric strength is demanded, and for this purpose it is far better than any other filler which might be used.

Among the organic materials, shellac adheres most strongly to mica, and therefore, forms the best binder for mica insulation. Very interesting data on micas, their corresponding characteristics and uses, are given in the following two classifications.[1]

1 From report by the British Electrical and Allied Industries Research Association, published by "The Electrician," April 14, 1922.

Trade Descriptions of Micas and Corresponding Characteristics

Class.	Mineralogical Group.	General Characteristics.	Relative Hardness.
Ruby	Muscovite.	Colour, pale reddish brown (ruby red in plates 15 mm. thick).	Hard.
Soft White ...	"Altered" Ruby Muscovite.	Slightly yellowish. Slightly calcined appearance.	Softer than ruby
Silver	"Altered" Muscovite.	Slightly calcined (silvery) appearance. Wavy surface.	Hard as ruby.
Green	Muscovite.	Inclined to have internal cracks.	In greater crystalline tension than ruby.
Brown	Muscovite.	Ditto.	Ditto.
Amber	Phlogopite.	Colour, very pale yellow to dark or opaque. Wavy surface. Great expansion at right angles to laminations.	Soft.
Altered or Silver Amber	Phlogopite.	Naturally altered amber. Colour same as unaltered amber, but more metallic. Silvery and opaque.	Softer than unaltered amber.
Black Amber ..	Biotite.	Very dark green or brown in thin sheets (about 0.003 in.). Black and opaque in thicker plates (0.01 and up).	More brittle than amber.
Lithia Mica ...	Lepidolite.	Light mauve, yellow grayish white or white. Will not stand heat and fuses at ordinary flame temperature.	Very hard and brittle.

Micas Suitable for Specified Purposes.

Commutators.

Flush Segments ..... Amber and Silver Amber. Green and Brown.* Certain Grades of Soft White.

Undercut Segments ..... } Any sound micas which will cleave readily.
Rings and Cones ..... } Black Amber.*

Wrappings, Channels, Tubes and Washers.

Extra High Tension ..... 7,000 V and over: Ruby Clear A and B. Below 7,000 V: Any mica not spotted.

High Frequency .....

Condensers.

High Frequency ..... Ruby Clear A. Green or Brown Clear.*
(above 2,000) " " B, not considered suitable.

High Temperature Purposes.

Spark Plugs ..... Ruby Clear, Ruby slightly stained or stained.*

Pyrometers ..... Green or Brown.*
Ruby Clear A, and possibly other micas.*

Furnace Work ..... *Insulation:* Any mica which has the necessary mechanical characteristics.
Arc Resisting: Muscovite where mechanical requirements predominate. Phlogopite where ability to resist great heat is required.

Heating and Cooking ..... Muscovite where mechanical requirements predominate. Phlogopite where ability to resist great heat is required.

Mechanical and Optical.

Diaphragms	Lithia mica. Ruby Clear A.†
Windows and Spectacles	Any clear mica.
Dials, Vanes, and Compass Cards.	Any uniform flat mica.

Silica and Its Compounds. The element silicon—Si—in combination with two atoms of oxygen, forming the compound SiO_2, is generally known under the term of silica.

Silicon itself does not occur in the free state on account of its great tendency to combine with other elements; but it is found in abundance in a great many of its compounds, which are of greater importance in connection with molded electrical insulation than any other organic or inorganic ingredient employed.

This is due chiefly to the higher heat-resisting properties and chemical inertness of silica. The hydrosilicate of alumina—Al_2O_3, $2SiO_2$, $2H_2O$—is used in the manufacture of hydraulic cements and porcelain. In the manufacture of the latter, free silica in its various forms, such as quartz, flint, and sand, or combined silica in the form of silicates,, e.g., feldspar, serves as an opening refractory, or as a flux material.

The silica also occurs as chief constituent in a further variety of minerals such as kieselguhr, asbestos, mica and talc, all used in the manufacture of electrical insulation.

Silica combines readily at low temperatures with sodium or potassium hydroxides to form silicates according to the equation:

$$4\ NaOH + SiO_2 = Na_4SiO_4 + 2H_2O$$

The soluble silicate thus formed, which is generally known as waterglass, is much employed in the electrical art as a fireproof coating and has been the subject of considerable investigation and experimenting for its use as an inorganic binder; it can not be said, however, that these efforts have been rewarded with any marked success.

Hydraulic Cement. The term hydraulic cement is used to define that class of cements which will harden under water.

This product plays an important part in the manufacture of Molded Electrical Insulation because of its characteristics as a fireproof binder of materials of Class D, now so widely used in the electrical field.

The essential ingredients of all hydraulic cements are silica, alumina, iron oxide, and lime. In addition to these, magnesia and other impurities are usually present, together with substances added to control the time of set. Of these latter, calcium sulphate is almost universally used.

Alkaline Earths. The alkaline earths to be considered in connection with molded insulation are lime and magnesia.

In the manufacture of porcelain, the presence of these ingredients is necessary on account of their fluxing action. They are sometimes added in the form of chalk, or of dolomite (a double carbonate of lime and magnesia), and sometimes in the form of feldspar.

Lime and magnesia are of equal importance in connection with the inorganic materials of Class D. Considering hydraulic cements, lime is an essential ingredient of all cements that have been successfully used

as binders in Class D. For this purpose the lime is usually supplied by limestone or marl used in connection with clay, shale, or other silicious and aluminous materials. The physical characteristics of the ingredients are of little importance, since the burning in the rotary kiln brings about a complete metamorphosis of the materials.

Lime is also present in practically all inorganic binders other than hydraulic cements. The action of these binders is dependent upon the formation of calcium silicates and aluminates.

Magnesia is the characteristic constituent of most oxy-chloride and similar cements, often spoken of as Sorel cements. When properly made, Sorel cement is superior in strength to Portland cement, but as commonly made is liable to have certain drawbacks, due to improper methods of preparation. For example, if the magnesia contain a small quantity of residual carbon dioxide, the cement, although attaining great strength, is apt to crack badly during setting; if the magnesium chloride contain sulphuric acid, as is frequently the case, the durability and appearance of the cement are very much injured. The principal defect of such cements as they are ordinarily manufactured, is that they are not as proof against climatic action as the hydraulic cements.

Vegetable Fibers. The vegetable fibers most frequently employed in the manufacture of molded electrical insulation are wood pulp and cotton, and to a lesser degree, hemp, flax, and straw. They are employed for the same purpose as the mineral fiber, asbestos; namely, to impart strength and flexibility to the material.

Vegetable fiber, when used in the manufacture of the organic hot molded products, Class C, and the phenol-formaldehyde Class A materials, is chemically inert and performs merely a physical function in adding mechanical strength and toughness to a merely mechanical mixture.

Vegetable fibers have been extensively employed by makers of molded insulation because they impart a fair degree of mechanical strength and owing to the fine structure of these fibers they are more easily compounded and molded than mineral fiber and consequently the product comes from the dies with a finer and more finished appearance.

Another desirable quality is that, being of a soft nature, materials in which they are employed, have a very much less abrasive action on the dies than those employing mineral fiber. But as they char at about 150 deg. C., they are unsuited to the manufacture of materials to be subjected to that or a higher degree of heat.

Furthermore, their use has been practically restricted to materials employing organic binders and particularly to such using the hot molding process.

Numerous attempts have been made to use vegetable fiber in conjunction with the inorganic binders such as the silicate or other compounds of lime and magnesia, but with indifferent success for electrical insulating purposes, for while these inorganic substances partly combine with the mineral fillers and make good binders, they do not combine with the organic fillers and their binding value, when used with these

fillers is small, just as when sawdust is employed instead of sand to make mortar with hydraulic cement the sawdust, not bonding with the cement, the resulting mortar is much less strong than when sand is employed.

As an exception, the magnesium chloride cements should be mentioned, which are extensively used as binders for vegetable fiber; but such compounds have not been employed to any extent for electrical insulating purposes and for such purposes vegetable fiber is used only in connection with the natural organic or resinous binders molded under heat.

In case of materials of cellulose nature and the sheet materials of Classes G and H, however, the vegetable fiber plays a more active part. In the former it is employed for its basic chemical principle as cellulose while in the latter it is employed for its physical structure, the other ingredients being employed solely for their chemical or physical action upon it.

The proper choice of the vegetable fiber in materials of Class G is of first importance as in this material it undergoes definite chemical or physical changes which take place under conditions requiring the most careful control.

Cotton. Cotton is a plant of the genus Gossypium. It is one of the most important vegetable fibers, and on account of its characteristic spiral thickening is readily distinguished from all others and is especially adaptable to spinning.

At least fifty species of Gossypium are known, nearly all of which produce lint upon their seeds, but very few enter into consideration in the production of the commercial crop.

The Upland cottons of the United States are variously referred to as "Gossypium Herbaceum" and "Gossypium Hirsutum."

In this country two distinct types of cotton are recognized. The Sea Island, with its small, smooth, black seeds, and long, fine lint, and the Upland type with a greenish seed, shorter lint, and a closely adherent fuzz about the seed known as linters.

The Sea Island cotton is grown to greatest perfection on the islands and low-lying coast of South Carolina, Georgia, and Florida; also in the West Indies and in Egypt. The fiber, when well-grown, measures 1.5″ to 2″ in length, and being very fine, is in constant demand for the finer numbers of threads and yarns, for which it commands a high price.

The Upland cotton is grown over a wide area of the United States and furnishes by far the greater portion of the crop. It is cultivated throughout the region from Virginia to Oklahoma, and southward. The fiber of this Upland type is usually shorter and coarser than that of the Sea Island, but by careful crossing and selection, varieties are being secured that approach the lower grades of Sea Island in quality.

Cotton is an initial raw material in the manufacture of celluloid and its treatment for such is described under the chapter devoted to that material. From it, the better qualities of the vulcanized fiber or other products, of Class H are made; also it is used in compounding of hot molded organic materials.

Flax. Flax, or Linum Usitatissimum, belongs to the natural order of Linaceae and is unknown in the wild state. Its cultivation dates from pre-historic times, bundles of unworked flax having been found in the ancient lake dwellings in Switzerland.

The flax fiber is found within the cortex of the stem and is easily separated after the flax straw has been rotted in water. This process is followed by drying and stacking, and afterwards by breaking and scutching, which completely separates the fiber.

Flax is produced principally in Austria, Belgium, France, Germany and Russia. It is also grown in the United States, but in this country it is cultivated almost entirely for its seed and not for its fiber.

The flaxes are herbaceous or sub-shrubbery plants, their stems being remarkably tough.

New Zealand flax is a liliaceous plant and also yields a valuable fiber, which is stripped by machinery and used for making baskets, ropes, etc.

Hemp. Cannabis Sativa is an erect growing plant originating in Asia. It resembles very much in its general appearance the common stinging nettle. Both belong to the same family—Urticaceae.

Its cultivation is similar to that of flax. The young plants are thinned out when they are three or four inches high, and are left from eight to twelve inches apart. If intended for fiber alone, the stems are all pulled and treated alike and it is principally for its fiber that hemp is cultivated. This is obtained by rotting the stems of the plant, on the same principle as is followed in separating flax fiber.

Hemp is grown in the Philippine Islands and in various parts of Europe.

Wood Pulp. This product is obtained by disintegrating wood. The wood fibers are separated either mechanically or chemically.

Mechanical wood pulp is prepared by grinding the wood under water, and is of inferior quality, as the fibers are short. The superior grades, so called sulphite pulp, are prepared by chemical means. The wood is cut up and boiled under pressure with a solution of caustic soda, sodium sulphite or, best of all, calcium bisulphite, and the resulting soft product is pulped, pressed, and washed.

A special grade of wood pulp is used as raw material in the manufacture of certain low priced celluloids. It is used extensively as a filler in such hot molded materials as of Class C and in the phenol-formaldehyde products of Class A.

Camphor. Camphor plays a very important part in the nitrocellulose industry, as it forms with pyroxylin or nitrocellulose a so-called solid solution generally known as celluloid, a plastic of remarkable flexibility and elasticity.

Numerous attempts have been made in the celluloid manufacturing processes to replace camphor with cheaper substances, but hitherto such efforts have met with little success.

Asphalts. The term "asphalt" is applied to a series of bituminous substances generally black in color, which are hard at ordinary temperatures, become viscous at about 70 deg. C., and melt at about 100 deg. C.

Their specific gravity varies from 1.04 to 1.40. Chemically, they are compounds of carbon and hydrogen containing also sulphur and nitrogen.

They may be divided into two groups; the natural and the artificial. Natural asphalts occur in various parts of the world, notably in United States, Trinidad, Barbadoes, Venezuela, Mexico, Cuba, Egypt, Russia, and India. They are found as mineral deposits embedded in the earth, sometimes containing lime and other impurities, or in the so-called asphalt lakes, such as those in Trinidad and Venezuela.

The asphalts in which we are particularly interested are the mineral asphalts of Utah, Colorado (Gilsonite) and Barbadoes (Manjak), which are peculiarly free from impurities and are the ones generally employed in the manufacture of electrical insulation.

The artificial asphalts, prepared by the distillation of asphaltic petroleum, resemble the softer natural asphalts in some respects and are often marketed as such, especially when prepared for some specific purpose.

Pitch. In addition to the natural and artificial asphalts, coal tar residues, or pitch, derived from the distillation of coal tar, are extensively used for many similar purposes. Coal tar pitch differs materially in chemical composition from the natural bitumens. It is more brittle than the hard asphalts, but melts more readily and is more fluid under heat. The artificial asphalts and coal tar pitch are both extensively used in the manufacture of electrical insulation and for this purpose are about equally as valuable as the natural asphalts.

Stearin Pitch, obtained as a by-product in the treatment of vegetable and animal oils and fats for the production of stearic acid in the manufacture of candles, is much softer than those mentioned above and is of great value in insulating compounds, because of its ability to stand very high temperatures without drying out and becoming brittle, and is employed in the manufacture of insulating varnishes, cloths, and tapes, as well as in binders for the manufacture of molded insulating parts.

Ozokerite, a natural solid bitumen, consisting largely of paraffin hydro-carbons, and ceresin wax prepared therefrom, are important raw materials used for insulating purposes. Ceresin wax melts between 60 deg. C., and 70 deg. C., and owing to the fact that it then becomes a very limpid fluid, it has much higher saturating qualities and is a far better impregnating material for tapes, cloths, and molded insulating pieces than the heavier and more viscous asphalts or pitches.

Pitch obtained from distillation of wood and lignite coal is also used to some extent, but owing to its very brittle nature is of comparatively little value.

It is self-evident that the harder the asphalt, that is, the higher its melting point, the greater will be its heat-resisting properties, but unfortunately, the brittleness increases with the hardness.

The chemical and physical characteristics of some asphalts are such that they are well suited for use in compounding with rubber, and for this purpose are extensively and successfully employed.

Pure asphalts and mineral pitches are unaffected physically or chemically by water, acids, or alkalies and this inert character coupled with their high dielectric strength, their low cost, and the facility with which they can be manipulated, renders them of the greatest importance in the manufacture of electrical insulating materials.

They have a considerable advantage over the copal resins in that they do not have to be distilled to render them suitable for the manufacture of varnishes and other compounds used in the preparation of binders employed in the manufacture of molded insulation, as they fuse or melt readily when subjected to heat.

Shellac. The story of the production of shellac is perhaps more interesting than that of any other material used in the manufacture of molded insulation.

Lac is a vegetable substance as it is the sap of a tree, but it is also an animal product in that it is exuded by an insect.

These insects (the Coccus Lacca, Carteria Lacca, etc.), infest several species of trees growing in India and southern Asia, notably certain varieties of fig trees.

The female produces the lac to protect her eggs. This insect, after attaching itself to the plant, remains fixed there and proceeds to extract the resinous sap and to convert it into lac, with which she incrusts herself and in which she deposits her eggs.

In a short time, the eggs burst into life, and the young, which are very minute, eat their way through the dead body of their parent and swarm all over the twig or small young branch of the tree in such countless numbers as to give it the appearance of being covered with a blood-red dust.

The method of preparing the lac for market is crude but effective. The incrusted twigs, when broken from the trees, are known as stick lac. The brittle lac is readily removed from the sticks by means of rollers.

The crude lac, which is of a dark red color and contains about 68% resin, is now placed in tubs of warm water and beaten with pestles or trodden by men. By this means it is freed from the bodies of the insects, the dirt, vegetable matter, and much of its coloring.

The lac, now termed seed lac, is removed from the refuse and then later boiled down and molded into cakes. This product, known as lac-lake, before the introduction of coal tar colors, was very widely used as a red dye for textiles, and is still much used in the countries where it is produced.

The seed lac is now placed in cotton bags and held before a charcoal fire, the melting lac being squeezed through the cloth by twisting the bag. It is now ladled from the trough into which it has dropped and poured over and spread upon a slowly revolving roller upon which it soon sets and hardens, when the thin shell of lac is cut or scraped from the roller with a knife, and the shell lac, or shellac, is ready for market.

The best of the shellac made in this way is of a light brown color, nearly transparent, and is known as orange shellac.

The lower grades, not so free from coloring matter and foreign sub-

stances, are usually molded into thin sheets or discs and sold under the names of button lac, garnet lac, etc.

Shellac is chiefly used as a binder for materials of Class C. It melts more perfectly than asphalt or other natural resinous bodies, with the exception of rosin, although its melting point is higher than that of these adulterants.

It is impervious to water and stable under ordinary climatic conditions. It forms a very tough binder and is superior in this respect to asphalts, pitches and resins, but, unfortunately, quite liable to adulteration with the latter, owing to its higher price.

Shellac is also used as a binder for mica and its binding qualities for this material are superior to those of any other kind known to-day.

It is used extensively in solution in alcohol as a quick-drying insulating varnish.

It is, or ought to be, the principal ingredient in the manufacture of insulating sealing waxes, used for sealing metal parts in assembled porcelain insulators, but unfortunately, as in the case of molded insulating materials of Class C, it is commonly replaced for this purpose by cheaper resinous products such as rosins, asphalts, etc.

Copal. This term is broadly applied to a number of fossil gums. The botanical origin of these resins is not definitely known although some of them, particularly those of more recent fossil origin, can be partly traced to trees belonging to species still extant to-day.

The copals are found chiefly in East and West Africa, New Zealand, Java, South America and the Philippine Islands. The older fossils are collected by natives employing very primitive methods and are gathered from the beds of lakes and streams or dug from the earth during the wet season by open mining to a depth of about fifteen feet.

Copal is found in the market in many shapes and varies greatly in color. In form it ranges from small pebble-like particles to blocks two feet in diameter. The size depends on the kind of copal. It is also found as chips, slabs, and angular lumps of irregular form. It is usually of a yellowish or brownish amber color and is almost always covered with a crust of variable color, which must be removed in water or lye or by mechanical means, the latter method being preferable.

In quality copals are graded according to the following characteristics:

Hardness or toughness
Color
Solubility and melting point

The harder copals, Zanzibar, Mozambique, Sierra Leone, Angola, Benguella, Gabon, are usually the higher priced. Among the softer copals are the Manilla and the Kauri.

The melting point of copals varies from 75 deg. C. to 450 deg. C., the harder having the higher melting points.

The solubility of copal has been the subject of much analytical research and while many of these gums are more or less soluble in al-

cohol, ether, benzol, benzine, acetone, turpentine, chloroform and carbon disulphide, in manufacturing it is practical to dissolve them only after they have been melted. This process is briefly as follows: the copal, after having been cleaned, is sorted according to color and size and the larger pieces are crushed or ground. It is then heated to get rid of such water as may be present and then melted over an open fire or subjected to a process of destructive distillation to drive off the resinous oils. The loss from this operation varies from 10% to 40% by weight. The process is one requiring great care and experience, for the point at which the melting or distillation is arrested plays a most important part in the value of the product. This point is determined by collecting and watching the amount of resin-oil distilled over or by carefully watching the appearance, temperature, and condition of the melted resin and depending upon the skill and experience of the operator, the latter method usually giving the better results.

If the heating is carried too far and too much oil is driven off, not only is the loss in weight unnecessarily great, but the copal loses some of its toughness and other desirable qualities. The interruption of the distilling process at the proper moment is, therefore, of prime importance.

After being subjected to the distilling process, as described above, the copal gums are soluble in various oils and other solvents, and in such form are of the highest importance in the electrical art, not only in the field of molded insulation, but to an even greater extent for a wide range of uses in the preparation of insulating varnishes, impregnating compounds, insulating cloths, and the like. Copals and copal preparations, especially those of the earlier fossil origin, when properly prepared, are unaffected by climatic influences, and in proper combination with suitable solvents and inorganic admixtures they possess great heat resisting and dielectric properties and will withstand continuously a temperature of 200 deg. C. These properties render copal one of the most important materials in common use in the manufacture of molding compounds and insulating varnishes.

While the chemical nature of copals is as yet but incompletely determined, their physical properties render them of the utmost importance in the electrical arts.

Dammar Gum. This variety of resin is obtained from the Amboyna Pine and comes principally from Java and Sumatra. It exudes sap naturally like the spruce and other members of the pine family, but this yield is increased by making incisions in excrescences which grow on the trunk of the tree. It is also gathered in considerable quantities from the beds of streams flowing through the districts in which the tree is found. It comes to the market in small, usually transparent, homogeneous lumps. Its principal use in insulating manufacture is in binders for the hot molded organic materials of Class C.

It begins to melt at 80 deg. C., and at 100 deg. C. it commences to flow rapidly. It melts less readily than rosin, but more readily than resins of the copal series.

It is soluble in benzol, turpentine, and ether without the application

of heat. It is also soluble in benzine, wherein it differs from most other resins.

Rosin. The solid residue left behind in the still at the end of the distillation of turpentine from pine sap is known as rosin.

Rosin comes to the market in hard, homogeneous masses and varies greatly in quality. The quality depends upon the percentage of turpentine distilled off as well as upon the quality of the resinous exudation from which it was derived. In color, it varies from a light, transparent, yellow amber to almost black. It is quite hard and very brittle and softens readily under heat at 75 deg. C., becoming a thin liquid at about 100 deg. C., above which temperature it decomposes.

It has the property of becoming a limpid liquid at comparatively low temperatures, which makes it so useful a substitute for shellac in the organic cold molded materials. It is not much used in the manufacture of electrical insulation, except for this purpose, but finds manifold uses in various of the liberal arts.

The use of rosin in the manufacture of molded insulation should be discouraged, since its cheapness is its only recommendation. Many attempts have been made to render it more heat-proof and to give it a more stable nature, but while much literature has been published on this subject, very little practical result has been attained.

Cumar (Coal Tar Resin). This is a new synthetic resinous substance, brought out commercially during the last ten years to be used as a binder in molding mixtures, insulating compounds, compounding ingredient for rubber, for making varnishes, waterproofing compounds, etc.

Chemically, it is a mixture of Para-coumarone, Para-indene and the polymers of other hydrocarbons of coal tar. Its appearance is similar to rosin, but unlike the latter, it is unaffected by atmospheric conditions, non-saponifying and withstands acids and alkalies. It is produced in various grades with melting points from 50 deg. to 160 deg. C. It is soluble in coal tar solutions, petroleum oil, vegetable oils, turpentine, and in practically all commercial solvents with the exception of alcohol.

The characteristics of this new synthetic resin are of considerable interest to the plastic molding industries and we may look forward to their wide and successful application for electrical insulation and their commercial purposes.

Paraffin Wax. This term is applied to a variety of hydrocarbons of the paraffin series, obtained as residues in the distillation of petroleum. Paraffin wax is a solid softening readily at 50 deg. C., and was formerly used for impregnating electrical insulation materials. But owing to its low melting point it is but very little used for such purposes to-day. Nevertheless, it retains its place among the substances in use for the manufacture of electrical insulating materials because it withstands the action of alkalies better than any other organic insulating substance. It is also unaffected by strong acids at ordinary temperatures.

Linseed Oil. This oil is obtained by pressing the seeds of the flax plant. According to the character of the seeds and the method of

extraction employed, the oil varies from a pale, tasteless product to an amber or yellowish colored, limpid liquid of characteristic taste.

It is of incalculable value in the electrical arts and is extensively employed in conjunction with resins and asphalts for the manufacture of varnishes and impregnating compounds. In such preparations, it acts not only as a solvent, but owing to the fact that it absorbs oxygen from the air, it has an oxidizing effect upon the resinous and asphaltic bodies with which it is mixed. This is particularly true of the boiled linseed oil, which will continue to increase in weight by the absorption of oxygen from the air until it becomes viscous or even hard. In practice, this drying or oxygen absorbing property is increased or hastened by the addition of metallic oxidizing agents.

Linseed oil is used not only in combination with other substances, but the boiled oil itself, without other admixtures, except, perhaps, driers, is used to a considerable extent for impregnating and coating cloths and tapes as well as for treating molded insulation and insulating parts.

A number of methods have been proposed and considerable patent literature is available relating to the production of solid resinous products from linseed oil which might be substituted for shellac, asphalts or resins in the manufacture of molded insulation. The object of these experiments was to take advantage of the high heat-resisting properties of the resinified linoxen products in the manufacture of organic molded materials, but no great success has been attained in this direction, partly owing to the fact that one of the chief advantages of employing shellac and similar binders for materials of this class lies in their property of becoming plastic under heat during the molding process, and the linoxen products are far less plastic than shellac and consequently are not so easily molded.

On the other hand, considerable success has attended the compounding of linoxen products with rubber and asphalts to produce rubber substitutes which are successfully employed in the manufacture of molded insulation.

Another interesting application of linseed oil which has been proposed, consists in heating cellulose, starch, refuse horn, hoof by-products, and other materials, with linseed oil to a temperature beyond the point of decomposition, at which temperature the components were supposed to react upon each other to form a new resinous substance. Unfortunately, beyond laboratory experiment and elaborate patent literature, nothing noteworthy was developed.

Owing to its high price, linseed oil is subject to much adulteration and replacement by rosin oil, mineral oils, and other cheaper oils, and, while it is often difficult to detect the presence of such adulterants analytically, their imperfect drying and poor elastic qualities soon proclaim them in practice.

Various Other Drying Oils. Besides linseed oils, there are a few other oils used in connection with the utilization of resins and asphalts for insulating purposes. Among such the following are worthy of mention:

Chinese Wood Oil or Tung Oil. This oil is obtained from the seeds of the Ying-tzu-tung, a tree indigenous to China, and is used in very considerable quantities as a substitute for linseed oil. This product exhibits one marked difference from linseed oil, in that it dries at a uniform rate throughout its mass, whereas the latter dries from the surface inward.

Soja Bean Oil. Obtained from the fruit of the Soja bean tree.

Poppy Seed Oil. Obtained from the plant Papaver Somniferum.

Rosin Oil. Obtained from the dry distillation of rosin. This oil, owing to its low price, is a common adulterant of linseed oil. Its drying qualities are not equal to those of linseed oil and it is of such an unstable nature as to make its use inadvisable for electrical insulating purposes.

Mineral Oil Solvents. Various derivatives distilled from petroleum and coal tar at different temperatures are employed in the manufacture of liquid compounds of resins and asphalts.

They are usually cheaper than the drying oils and do not dry, or rather evaporate, readily, which is a source of frequent complaint from users of these liquid solutions or compounds.

They are employed in the manufacture of impregnating compounds and cheap insulating varnishes, as well as for impregnating insulating cloths and tapes.

Their evaporative qualities vary greatly. Some will dry or evaporate on exposure to the atmosphere, while others require considerable heat. This variation renders them applicable to a wide range of purposes.

Turpentine. This well known solvent is obtained from the distillation of the exudations from various species of the pine tree. It is the volatile product of the distilling process, the residue being rosin. It is much valued for its use in connection with dissolving waxes, resins, and similar materials used for electrical insulating purposes. When exposed to the air, it dries slowly but steadily by absorbing oxygen. The major part of it evaporates, leaving a minor part of resinous hard substance behind. In this respect of drying by absorption of oxygen, turpentines differ from other solvents, such as naphtha, benzol, etc., as these latter solvents evaporate rapidly and leave no residue behind.

Benzine and Benzol. Benzol obtained from the distillation of coal tar, and the benzine or benzoline obtained from the distillation of petroleum oils, are both widely used as quick volatile solvents for asphalts, resins, and copal oil compounds, because of their excellent dissolving properties and volatile characteristics.

Alcohols. Among the alcohols ethyl or grain alcohol and methyl or wood alcohol are both used to a considerable extent for dissolving the resinous organic binders in the manufacture of insulation products. They are principally used to dissolve shellac and other alcohol-soluble gums. Such solutions are also of great importance in the manufacture of built up mica and quick drying shellac gum varnishes.

Caoutchouc or Crude Rubber. This is the name given to the product of the milky latex which exudes from incisions made in the bark of certain trees found in tropical and semi-tropical countries.

While many trees produce the latex to a greater or lesser degree, there are certain regions in which the quality and quantity of this product surpass all others. At the present time the rubber trees found in the Amazon District of South America give a latex which in purity and quantity surpasses any now known. Generally speaking, the world's supply of crude rubber comes from Central America, South America, Africa, and Asia. The quality of the rubber is rated in the order named.

As an electrical insulator rubber must be rated highly. It has been found that rubber in its unvulcanized state has a higher dielectric strength than after being vulcanized and that compounding with chemicals and minerals decreases this property in proportion to the percentage of chemicals and minerals used.

Inasmuch as sulphur is also a good insulator, crude rubber, mixed with sulphur alone, is sometimes used for electrical work, but on account of the cost of the rubber, compounding with fillers to the extent of 50% to 90% is often resorted to.

While many substitutes for rubber have been offered, they lack the excellent toughness and elasticity which rubber possesses and till such substitutes can be produced possessing these qualities and at a lower cost than rubber, the latter will continue to hold its own.

Vast amounts of money and effort have been expended throughout the civilized world in attempts to produce rubber by artificial means and it seems as if at last success was in sight.

These efforts have for some time past centered on the cheap production of isoprene, the essential constituent of India rubber.

The new process from which so much is expected is based on using starch as an initial raw material, producing therefrom amylalcohol by a process of fermentation and converting the amylalcohol by certain chemical manipulations into the unsaturated hydrocarbon isoprene.

Isoprene had previously been produced from various substances, such as turpentine, acetylene and ethylene, but due to the high and fluctuating cost of these materials, the production of synthetic rubber had not made any remarkable progress until the discovery of a method of deriving isoprene from so simple, cheap, and readily obtainable a material as starch.

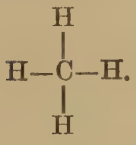
Isoprene when properly treated will polymerize into rubber.

The process here referred to is comparatively new and it is too soon to make positive predictions as to the success of this very interesting development in this important art, but the future of a process depending on so cheap and simple a raw material is full of interest.

Formaldehyde. This substance finds application as a hardening agent in various compositions, such as, for example, those containing casein and those containing gelatin. It is also one of the essential raw materials in the manufacture of the artificial resinous substances of Class A from which the most important hot molded insulators are made.

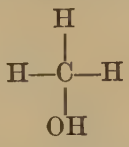
For the benefit of those readers who are not versed in organic chemistry, the chemical relationship of formaldehyde may be briefly indicated. The simplest hydrocarbon (compound of carbon and hydrogen) is methane, CH_4. In this, one carbon atom is united to four hydrogen

atoms thus

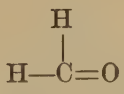


Alcohols are bodies containing the hydroxyl group OH.

The simplest alcohol is wood alcohol or methyl alcohol CH_3OH, or



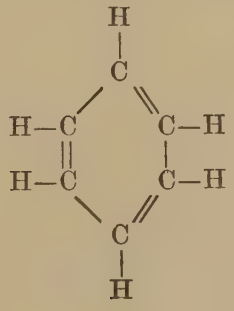
By oxidation this loses two atoms of hydrogen and is converted into formaldehyde CH_2O or



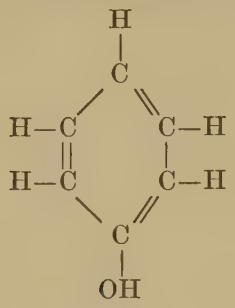
Methyl alcohol, commonly called wood alcohol, is obtained commercially as a product of the dry-distillation of wood, as the name implies. The oxidation of wood alcohol to formaldehyde is effected by passing the vapors of the alcohol, mixed with air, over a so-called contact substance or catalyst (granulated copper).

Formaldehyde itself is a gas. Commercially it is marketed in the form of an aqueous solution of about 40% strength which goes by the trade name of Formalin. Certain solid modifications of formaldehyde are also upon the market.

Phenol (Carbolic Acid). The carbon compounds derived from coal tar are for the most part not derivatives of the simple form of hydrocarbons of which mention has been made in connection with formaldehyde above, but are related to a more complex hydrocarbon benzene, (benzol) C_6H_6, in which the six carbon atoms are united in a ring



Here also the hydrogen atoms may be replaced by the hydroxyl group OH. The simplest of the derivatives thus formed is C_6H_5OH.



This substance is known as phenol, or, in the trade, more commonly as carbolic acid.

Our interest in phenol in connection with electrical insulators arises from the fact that this substance, under suitable conditions, reacts with formaldehyde, forming sticky resinous substances, which will be further discussed under hot molded phenol-formaldehyde materials of Class A. These synthetic gums, however, are not only of importance in connection with molded materials, but they become an increasingly important factor in the light of practical and theoretical considerations for the production of varnishes, impregnating compounds, and other products used in the liberal arts.

Insulating Varnishes. Varnishes play so important a rôle in electrical insulation that this chapter would be seriously lacking in completeness without some consideration of this class of substances, even though it may seem somewhat of a stretch to include them strictly under plastic materials. They are, certainly, very closely related to plastics, being for the most part solutions of such substances as shellac, resins, asphalts, synthetic gums or the like in a variety of solvents.

Varnishes not only serve in themselves for insulation (as a coating on wires) but also add to the insulating qualities of other substances such as paper, cloth, etc., partly by filling pores, and partly by excluding moisture.

In addition to varnishes composed of resins and waxes dissolved in water, turpentine, alcohol, or benzine, there is a second class of insulating varnishes which depend on the use of such oils as linseed or Chinese wood oil (tung oil), so-called "drying oils." These oils possess the property of absorbing oxygen from the air, whereby they become converted into a tough skin. Many varnishes contain both components of the first kind (solutions of gums, copal, resins, rubber, pitch, asphalt, waxes, etc., in turpentine, benzine, etc.), and a drying oil.

A good insulating varnish should withstand 1000 volts in films one thousandth of an inch thick. It must form a tough, strongly adhering coating reasonably stable towards temperature changes and moisture. Where applied to iron parts it should possess good rust-proofing quali-

ties. Both air-drying and baking varnishes have their proper field; the former, for example, is suited for coating aerial line wires. Varnishes made with drying oils set more slowly than those containing volatile solvents, and it is found that the quality of such oil varnish coatings is improved by slow drying. The adhesion of the varnish should be sufficient to permit of the bending of the insulated wire or sheet without cracking off the coating.

Certain varnishes known in commerce as Japan varnishes, though they are not true Japan varnishes, contain either asphalt or resin dissolved in wood oil. In their preparation asphalt, copal, resin, wood oil, tar, benzene, linseed oil, turpentine, etc., and sometimes sulphur are employed. These varnishes are very stable towards atmospheric influence and also resist acids and alkalies quite well. These asphalt varnishes are divided into two classes, air drying and baked varnishes. The latter in particular are very suitable for electrical work.

Among the more modern developments in insulating varnishes are those prepared from phenol-formaldehyde condensation products. Either solid or liquid condensation products of this character are dissolved in alcohol with the addition to petroleum ether, benzene, toluene, etc. The condensation products must be used in their unbaked form since it is only in this form that they are soluble in alcohol, acetone, etc. Some of these products have been subjected to tests and have made a very good record.

CHAPTER III

CLASSIFICATION

CLASS A—HOT MOLDED PHENOL-FORMALDEHYDE PRODUCTS

A type of molded insulation which has proven of interest during recent years in electrical, chemical, mechanical and other arts is that containing phenol-formaldehyde resins. Manufacturers who have successfully entered into commercial production of insulators made from this synthetic resin have through their research laboratories and printed data published and given out considerable patent and other literature on the characteristics, adaptability, and scopes of these new products and have made them well known to designers and manufacturers of electrical appliances.

For many years it has been known that resinous substances could be derived by the reaction between phenol and formaldehyde. Baeyer made resins from phenols and aldehydes in 1872. Somewhat later Kleeburg conducted experiments with formaldehyde and phenol and obtained complex resinous condensation products. In 1900 Smith proposed the application of phenol aldehyde resins for making electrical insulation. He used asbestos as a filler. Smith was followed by Blumer who made a substitute for shellac from these chemical compounds. Luft produced a molded composition and also obtained transparent products. Luft suggested the use of the material in making electrical insulating materials and articles such as buttons, handles and billiard balls. About the year 1905 Story also produced molded materials, one being a black product resembling ebonite. deLaire in 1906 produced an infusible molded composition from phenol and formaldehyde. In more recent years progress has been made in the commercial application of these resins through the work of Baekeland and others in this country and several investigators abroad.

This molded material has been introduced into the electrical and other arts as an advantageous substitute for organic hot molded (shellac) or hard rubber materials, although used in a restricted way because of its high cost. Some of the uses of the material, such as in the production of ornamental articles, billiard balls, pipe stems and similar articles, which come prominently into public notice, have served to advertise the product to an extent which has attracted attention to it possibly to a greater extent than its actual importance, particularly in the electrical field, warrants. During this period of development the cold molded process was getting a commercial start in a far less spectacular manner but nevertheless was meeting a demand for molded insulation and other materials of a far greater magnitude than that found possible with phe-

nol-formaldehyde resins. As the pioneer in the development of cold molded insulation in this country and as one who has seen its commercial development expand rapidly from the inception of the industry, the author feels that this comparison and ranking of the two processes, mentioned above (that is, Hemming's cold molding process and the hot molding with phenol-formaldehyde resins) should be fairly stated and due credit given the cold molding process for the advance which it made in the art.

Bakelite, Condensite, and Redmanol are trade names, under which the molded products of this phenol-formaldehyde group are best known and widely used to-day.

The serious interference with the proper and reliable operation of electrical apparatus and devices, caused by the softening or inflaming of the molded insulating parts made of the well known shellac materials, Class C, has caused electrical designers to eagerly seek a more heat and fire resisting product. The replacing of shellac by a binding medium which would have all the valuable molding qualities of this material without its serious defect of softening after molding at comparatively low temperature, has not only been highly desirable, but absolutely necessary, as will be observed in a later discussion of the well known hot molded organic products, Class C, where attention will be called to their most serious defect, namely, their low, scant resistance to heat due to the low melting point of their chief binding mediums.

However, for purposes of molded materials, the expedient well known in the hot molded (Class C) process of incorporating such fillers as wood flour or asbestos has been taken advantage of to overcome the brittleness of the phenol-formaldehyde resin. The products made with wood pulp have the advantage of being more easily molded and leaving the dies with a more elegant appearance. Those made with asbestos fiber are inferior in this respect but resist heat better.

The research work done along this line consisted in combining phenol with formaldehyde by means of heat, with or without the presence of acid or alkaline agents, to act as catalysers, causing the mixture to condense, eliminating the water by evaporation, or otherwise separating it from the viscous, condensation product.

Various phenols or aldehydes and different proportions of the constituent materials, the kind of catalytic agents used, the length of time of heating and temperatures, all affect the character of the condensation process and of the resulting compound, which is first a viscous liquid and then a hard, fusible solid, which on further heating polymerizes into an infusible product.

Phenol-formaldehyde resins as employed in molding compositions possess the disadvantage that in their commercial form ammonia is generally used as a catalyst and when the molded piece is subjected to heat below the carbonizing point the ammonia produces blistering. Not infrequently this occurs when molding at too high a temperature or because of removal of the molded piece too quickly from the press without adequate cooling.

The so-called phenol-formaldehyde molding mixtures to-day are

made by various methods. One manner in which the incorporation of the fillers is accomplished is by heating the mass obtained by the condensation process only to a point where it is plastic when hot, but hard when cold. It is then cooled and ground to powder and mixed in suitable proportions with the fillers. This mixture is placed in heated dies and held under pressure until the binder is first rendered plastic and then transformed by sufficient high heat into the hard infusible state. The dies are then cooled sufficiently to permit the removal of the molded pieces. Such pieces leave the dies in a finished state just as the shellac compounds do.

Another method of producing molded articles of this class is to mix the viscous condensation mass directly with the fillers, heating the mixture just to a sufficient degree to make it hard when cold, but plastic when hot, either molding the sheets or grinding them to a powder and subjecting this powder to the same treatment as described above.

Still another method is that of dissolving the resin in a solvent such as alcohol or acetone and impregnating the filling material with the solution. After thorough impregnation the mixture is dried in a vacuum pan. It is customary to add a small amount of a substance called hexamethylenetetramine, a product made by combining formaldehyde with ammonia, in order to assist in forming the infusible binder when the composition is subjected to heat and pressure.

In all cases, the mixing-in of the filling materials and the molding of the compounds must be done before the binder reaches its infusible state. Generally the molded phenol-formaldehyde parts on the application of a flame, give off a carbolic acid odor. This is overcome by subjecting the molded materials to a further exposure to heat.

In some instances, the molding concerns purchase the pure phenol-formaldehyde resins only and incorporate same with some such fillers as wood pulp or other cellular material, asbestos, mica, lamp black, zinc, calcium, magnesium or silica compounds, etc. In other instances, such fillers are incorporated with the synthetic gums directly by the manufacturer of same and sold as complete molding mixtures to the molding concerns.

Molded products of this class are insoluble in acids and in practically all but alkaline solvents, are unaffected by temperatures of from 300 to 500 deg. F. and possess great mechanical strength. They have extremely high dielectric resistance.

While the various manufacturers of the phenol-formaldehyde materials claim marked differences in their products; the characteristics of the binders are the same, therefore any difference is mostly dependent upon the character of the fillers, and the care and knowledge exercised in the various manufacturing steps.

Phenol-formaldehyde resinous substances are manufactured in form of molding resins, or molding mixtures, by concerns doing no molding themselves, and sold to others whose function is to do the molding. This plan is to-day exclusively followed in this country, an entirely new and distinct procedure from that followed by the manufacturers of the molded products of all other classes. In so separating the chemical

process of obtaining the resinous synthetic gums from the molding operations, the manufacturer of these phenol-formaldehyde condensation materials is able to concentrate all efforts to employ scientific methods, systematize the analyzing of raw materials, and checking of every step of the chemical condensation process, in order to control and obtain the desired results in the final resin, which must be perfect as to its required melting, softening, and flowing properties.

The molding concern then, with the known factors of the molding mixtures at its command, is thus enabled to devote all its attention to the technical control of the numerous manufacturing steps entering into the molding operations, from the designing and construction of the necessary steel molds to the final checking up of the dimensions of the finished molded part, and the testing of its mechanical, physical or dielectric properties, to conform same to the required specifications.

During the last six years considerable research has been devoted to furfural and other substances in connection with the production of synthetic resinous materials and Dr. LaForge of the Bureau of Standards has worked out a process known as the LaForge Process to obtain a peculiar liquid compound called "Furfural" by treating corn cobs with steam under pressure. Another process has been developed by the Miner Laboratories to obtain furfural from oat hulls by treatment with acid. This process has been placed on a small manufacturing scale. A number of resins have been made from furfural by combination with other substances such as aniline and phenol. The researches of Carleton Ellis on synthetic resins have disclosed the interesting fact that numerous organic substances other than the resins obtained from phenol and formaldehyde, while quite different from them in chemical constitution, nevertheless possess the property of quickly hardening when exposed to heat. These and other investigators are advancing the domain of resins made by synthesis of organic compounds and the author predicts important developments in the field in the no far distant future.

CLASS B—COLD MOLDED ORGANIC INSULATION

The inception of the art of molded materials made under an entirely new and basic method, originated and introduced commercially to the electrical industry in this country by Emile Hemming and named by him the Cold Molding Process, dates back only to 1909; and during the intervening years has resulted in the establishment of an industry of far greater proportions with respect to output than the phenol-formaldehyde resinous hot molded plastics which have been undergoing commercial development during approximately the same period.

The scope and purpose followed by Hemming in his research work to produce a commercial heat resisting molded insulating product for extensive use, particularly in the electrical, the wiring device, and in the automotive fields, was to obtain a molded material, embodying the following main characteristics:

1. To be produced commercially for an unlimited range of uses, having such raw materials enter into the production as would insure a

stable, continuous supply without danger of prohibitive fluctuations in cost.

2. To embody the heat-proof qualities of porcelain and its advantageous methods of quantity production with comparatively small cost of mold equipment, eliminating the brittleness and features of inaccuracy of porcelain, and to produce, by using organic substances as binders, a plastic compound which would mold better and with less wear on the molds than the ceramic or inorganic mixtures used in the then known cold molded inorganic products of Classes D and E.

3. To be in appearance, adaptability for molding, and dielectric properties similar to the known shellac materials of Class C, but not having their disadvantage of melting under low heat and inflaming and carrying the flame caused by temporary short circuiting of disarranged electrical connections.

4. To produce a molded insulating product able to withstand indefinitely the atmospheric conditions, both heat and water, without danger of deterioration.

In 1907 Hemming had his plans formulated to start the production of his new cold molded material in this country, a product which since has revolutionized the design and manufacturing methods of the electrical wiring device industry. Shortly after this the phenol-formaldehyde resins began to be utilized in making molded electrical insulation. Over a considerable period of years these resins were undergoing development and Lebach abroad and Baekeland in this country began the commercial exploitation at about the same time. The commercial molded materials made from phenol-formaldehyde resins were found to be better than the known hot molded shellac compositions of Class C because of their good dielectric and mechanical strength, high stability against water and the feature of heat resistance up to 500° F.

The American wiring device industry was hitherto handicapped through the lack of molded insulation possessing a heat resisting quality and Hemming's researches were particularly fortunate in resulting in the development and successful introduction of a material which would supply the required properties for the electrical wiring device field without undue expense.

The practically parallel commercial application of the phenol-formaldehyde hot molded compositions and Hemming's cold molded products have established the fact that while the hot molded compositions may yield a product of more accurate dimensions and of greater mechanical and dielectric strength, they do so at a cost considerably higher than that of Hemming's cold molding process. The latter process has developed on large scale production articles for electrical and other purposes which beyond question could not have been produced by the phenol-formaldehyde resins owing to their prohibitive cost not only in materials but in molds and labor costs. An immense field for the application and extension of cold molded organic products was opened through the pioneer work of Hemming and the development of this class of molded products has made exceptional progress, far surpassing, in point of production, those made from phenol and formaldehyde.

The appearance of materials of Class B is similar to those of Classes A and C, but the two latter types possess a higher lustred surface finish than the former and this difference to the expert eye is apparent. The chemical analysis of cold molded insulation would show a composition of inorganic filling materials and organic partly carbonized binders.

In the manufacture of these products, a variety of binders is used and each manufacturer claims to have some secret formula for the binder or combination of binders. The binders used are various asphalts, either natural or oil derivatives, coal tar pitches, stearine pitches, residues derived from distillation or utilization from oils and fats, a variety of solutions of gums or resins, oxidized oils, waxed compounds, etc., and with the later years specially prepared phenol-formaldehyde solutions have been adopted for the cold molding process.

The filling materials are principally asbestos fiber and such inorganic materials as infusorial earth, silica, and magnesia compounds, etc.

In materials of Class B, the fillers and the percentage composition in the molding mixture play a very important part in regard to mechanical strength. The binders in materials of Class B perform the functions of a waterproofing and cementing medium, while in materials of Classes A and C the filler is of secondary, but the binders of primary importance.

The mechanical incorporation of the binding materials with the fillers is done by first reducing the solid binders to a liquid, semi-liquid, or viscous condition by means of suitable solvents, such as coal tar oils, petroleum oils, drying oils, naphtha, benzine, turpentine, etc., the consistency of the desired liquid, semi-liquid, or viscous binder depending entirely on the formula and method as developed by each manufacturer. The subsequent pressing and heating methods are also devised according to individual ideas. Generally the mixing or incorporation of the binder with the filler is done in mixing machines similar to the types used in making Classes A and C materials. Mixing is usually done without the aid of heat, but in some instances heat is applied for the purpose of either hastening the mixing operation or driving off such solvents as are not easily volatilized, or oxidized during the mixing process.

The mixture when thoroughly incorporated and taken from the mixing machine must be in such plastic condition as to be moldable in closed molds to the required shapes and forms. If the mixture is too dry, that is, not plastic enough, it is either difficult to mold, not moldable at all, or liable to produce final moldings of porous nature. If the mixture is too plastic, on the other hand, the proper consistency cannot be obtained by molding and the molded piece could not be removed in intact shape from the mold. Emphasis must be given to the importance of preparing the molding mixture to just the required plastic consistency to enable favorable subsequent molding operation.

In this respect and at this point of manufacture, the cold molding process presents a difficult problem, not encountered in the molding of

the mixtures of Classes A and C materials, where the molding mixtures are in a dry state to be rendered plastic by pressure under heat. In the cold molding process, the binder must necessarily be, not in a dry, but in a plastic state, and as it is more or less affected by atmospheric conditions, if exposed too long before molding, it is apt to harden to such an extent as to be unsuitable for molding due to volatilization or oxidization.

The molding mixtures are usually in a fine granular state and for each molded piece the necessary amount must be weighed or measured out. This is either done by scales, volumetric measures, or the height of the mold casings is so calculated as to hold exactly the necessary volumetric measure to bring the molded part, after the pressure is fully applied, to the right dimensions. So-called overflow molds, as used in pressing molded porcelain, have not as yet proven very satisfactory.

The weighing methods are most common at the present time and while some manufacturers use a hand weighing method, others use automatic machines for this operation. The latter method appears to be the logical procedure, but in actual practice, its labor-saving advantages are partly offset by a number of drawbacks not encountered in the hand-weighing method. Automatic mold filling methods, automatic press operating, and automatic removal of the molded articles from the molds have been devised and put into actual service by some manufacturers but such advanced methods have proven to be somewhat premature for this comparatively young industry.

The pressure required for molding plastic materials in cold molds is necessarily much greater than when materials are molded under heat. A pressure of from two to five thousand pounds per sq. inch is necessary for welding the plastic mixture and giving it the required form. Usually, a flat shape requires much greater pressure than an irregular one. The variation in the consistency of the molding mixtures and the construction and design of the molds influence the amount of pressure to be applied.

After the molded articles are taken from the press, they are conveyed into heating ovens, so-called baking or enameling ovens, which are heated by means of superheated steam, gas, coal fire, or electricity. The temperature used to bake, dry, oxidize, or polymerize the molded articles in these ovens, is dependent upon the character of the binders used in compounding the original mixture and the time required for such heating is also governed by the thickness and shape of the molded product. Each manufacturer has his own oven and heating methods and so far there is no known standard for same.

The vital feature in this operation, however, is to heat the molded material to the proper condition and degree so that it will have all its volatile components driven off, its drying constituents so oxidized or the polymerization of its chemical action stopped at the point where the material has become hard and will no more soften.

The drying or heating of the previously pressed molding composition by means of evaporating or drying off a certain amount of volatile

matter, necessarily presents one distinct manufacturing disadvantage, not occurring materially with the molded products of Classes A and C. This is a shrinkage or a certain amount of warping in the dried finished product, varying from 2 to 20 thousandths per inch, according to the shape and design of the molded insulator. Years of practical experience have gradually made such shrinkage or warping known factors to the Cold Molded Insulation Engineer, to be considered when designing molds and advising designers of electrical devices for which cold molded insulation is specified. The electrical designing engineers are well enough accustomed to working with conditions of shrinkage of porcelain, which is about 125 mil. per inch, and to-day for all practical purposes, where cold molded material is specified and used, experienced manufacturers are able to fulfill strict specifications as to accuracy.

The heavy pressure required for molding cold molded insulation and the abrasive action under this high pressure of the large percentage of such mineral fillers as asbestos, silica, etc., in the composition, cause a serious wear and tear on the molds. Certain parts of the molds and even entire dies wear out under the cold molding process, or have to be replaced, sometimes after producing only 10,000 or 20,000 moldings, while others last through as much as 50,000 and 100,000. The longer the dies run without being renewed, the less perfect or accurate the molding will result. The surface of the mold pistons and mold casing will wear out, causing uneven surfaces and burrs which necessitate costly finishing operations on the hardened molded parts after removal from the baking ovens. The finishing operations are a serious factor in regard to the appearance of the final product as well as the cost of same. This together with the upkeep of fast wearing molds under continuous pressing operation, is a cost usually unforeseen by concerns not sufficiently experienced in this plastic cold molding process. The various successful cold molding concerns to-day have experienced that the maintenance of molds in proper condition and the finishing operations constitute an expense double and treble that of the actual pressing cost which latter is the chief labor item in the molding of hot molded shellac materials of Class C, and phenol-formaldehyde materials of Class A, where the mold upkeep is a very small item as compared with that of the cold molding process.

CLASS C—HOT MOLDED ORGANIC COMPOSITION

(Shellac-Compositions)

The ingredients of sealing wax and those used in producing molded insulation of this class have not varied from their earliest history. The binders play the important part in this type of materials, the principal ingredient of which is, or ought to be, shellac. Owing however, to the steady increase in the price of shellac, it has gradually been replaced almost entirely by cheaper materials, such as dammar gum, rosin, asphalts, pitches, and other cheap resinous substances.

Two methods are employed to combine the shellac binders with such fillers as wood pulp, magnesia, lime, plaster of Paris, sand, as-

bestos, and such coloring matters as lamp black, various metallic or earth pigments, and organic dye stuffs.

First: The organic binders are placed in a heated mixing machine in which they are melted, and when in a molten condition, the binders are gradually added and mixed. The mixture is then removed in a hot plastic condition and rolled into sheets. These sheets are broken into convenient sizes softened on steam tables and then placed in heated dies, pressed, cooled therein, and removed in a finished condition. The dies in this method are the open dies, described more fully under the section "Molds and Dies," of this book.

Second: The organic binding materials are dissolved in proper solvents and the mass mixed with the filler in about the same kind of mixing machines as in the first method, except that no heat is employed. The material is removed from the mixing machine and on exposure to the air the solvents evaporate, leaving an intimate, uniform mixture. This mass having become hard is ground to powder. Then the powder is placed in heated dies in which it remains under pressure until melted. It is cooled and removed from the die in a finished condition. The dies used in this method are called "closed dies," explained under section "Molds and Dies."

Manufacturers of products of this class vary as to minor details of the processes of manufacture, but all follow one or the other of the above mentioned fundamental methods. In most cases the first method is almost exclusively employed in this country. However, the author is familiar with the products of several molding concerns abroad who very successfully apply the second method.

Materials produced by either of these two methods differ but little in their properties. The second method, however, allows the incorporation of more filling material which increases the heat-resisting qualities of the final product, while in the first method, the amount of filler which can be added is restricted, for if too much is used, the plastic nature of the mixture is diminished and the material will not flow properly in the die.

The higher the proportion of the binding material the more plastic the molding mixture will be, and the cleaner the appearance of the finished piece. On the other hand, the higher the percentage of filler, especially when the filler is inorganic, the less plastic the material will be and the poorer the appearance of the finished piece, but it will be less subject to the softening influence of heat, which constitutes the most serious defect in materials of this class.

The composition of material of this class varies over a wide range, and the characteristics differ accordingly. If the binder is entirely free from rosin or cheap gums, these products are very stable and their life is long. Unfortunately, however, the general trend in the past has been to substitute rosin and dammar gum for shellac, which especially in the case of rosin, owing to its well known unstable properties, will cause the compound to deteriorate rapidly under climatic exposure.

However, rosin is extensively used because of its low price, and the advantage it possesses of being rapidly melted and molded at compara-

tively low temperatures, in which respect it is the best substitute for shellac. All other substitutes have the objection of requiring higher temperatures to melt and not being so readily molded in dies.

During the last ten years, numerous attempts have been made to substitute the shellac and other binders mentioned herein by some new rosin-like substances derived from coal tar, which were brought out under the trade name of "Cumar." The research work done and the purpose of this new resin are of considerable interest in connection with the molding industry of this class of materials, but the author has had no opportunity as yet to make himself familiar with the practical application of this new resin for molding purposes, although it has already been introduced and used in many molding mixtures of hot molded organic compositions, not as a direct substitute for shellac, but for replacing rosin and other binders.

Hot molded organic materials, of this class, when proper ingredients are employed, are practically non-hygroscopic, and moisture has no detrimental effect on their chemical or physical properties. It might be mentioned that such products containing a great excess of fillers, for instance, asbestos fiber, will absorb more or less water, but if properly made, even though they absorb moisture to a certain extent, are sufficiently impervious under ordinary weather conditions for ordinary voltages, if they contain no rosin.

Since none of the ingredients undergo any chemical change in the processes employed in the manufacture of these products, it is perfectly obvious that they will always soften at the temperature to which they are subjected in their mixing or molding processes. For instance, articles made with shellac, which softens at 80°C., will not withstand temperatures above this point; rosins, which withstand less, and materials made with soft bitumens, will soften in the sun's rays in hot weather. This is particularly true if the binders are in great excess in the mixture.

Such materials can be made so that they will withstand a momentary flame, and if not subjected to heat for too long a time, will not readily soften, but they will invariably fail as soon as a continuously applied temperature reaches the melting point of the binding medium.

The insulating properties of this class of materials vary quite materially. For instance, one specimen .001" thick may be punctured by 500 volts, while another of the same thickness will be punctured by 50 volts.

The reason for this great difference lies in the wide variation of ingredients in the compositions, although the finished products all have the same appearance. The higher the percentage of organic binder, the better the insulating properties; the lower the percentage of binder and the higher the percentage of filler, the poorer the insulating qualities will be. The more intimate the mixture between the filler and binder and the higher the pressure under which it is molded in the proper plastic condition, the less porous the product will be, and consequently the higher its resistance to puncture. These same features and conditions also apply to molded materials of Classes A, B, and F.

It might here be noted that various attempts have been made with

the purpose in mind to increase the heat-resisting properties of the molded products of this class by incorporating the filling compounds with a binder in a dissolved state, drying the mixture, molding hot, and heating or baking the product afterwards to render the binder more heat-proof.

Beyond very nice looking samples made by this baking method, the author is not aware that this process has resulted in commercial molded articles with worth-while increased heat-resisting properties, but there is in his opinion excellent opportunity for the research chemist to achieve results in that direction by diligent and systematic research work, as undoubtedly these materials can be considerably improved as to their heat-resisting qualities.

Several firms, both here and abroad, have, after long experiments, been able to produce this molded shellac material suitable for high tension insulation, which in some ways have considerable advantages over porcelain for such purposes, and great credit must be given to Louis Steinberger for his achievements in adapting molded materials of this class for high tension work.

Like Vulcanized Fiber, molded products of this class have been superseded for use in electrical appliances by other materials, due to their low melting nature; and had it not been for their adaptability and application in other industries, a sad history would be told of the hot molded shellac industry since the advent of such heat-resisting products as described in Classes A and B.

However, from the author's knowledge and observation, the gradually diminishing demand and use of these products in electrical applications, is being more than counterbalanced by their adoption into other industries where the requirements for a high heat-proof molded article do not yet exist. Yet if the manufacturers of these molded shellac products will do only a part of the experimental and research work of that done by the producers of Classes A and B insulation during the last fifteen years, and deviate somewhat from the hitherto practiced methods of continuing to make and mold their shellac mixtures like Sylvester practiced fifty years ago, materials of this kind will continue to find a wide field of usefulness.

CLASS D—INORGANIC COLD MOLDED MATERIALS

The process of making molded materials from hydraulic cements, in combination with an asbestos filler for the purpose of using such products as insulators in the electrical art, is in its practical commercial application about twenty years old, although at the beginning of that period, these molded insulators were very primitive and could hardly be compared with those evolved since.

The basic principle underlying the process and characteristics of hydraulic cement and concrete, discussed in an early chapter of this book, applies in practically every manufacturing step or theoretical consideration to the process of inorganic cold molded insulation, with the only difference that here asbestos fiber is used while in the making

of concrete, cement blocks, magnesia bricks, etc., sand and gravel are employed as a filler and reinforcing agent.

Cold molded inorganic insulating products, up to 1910, were the subject of great interest and importance, as before the advent of the phenol-formaldehyde hot molded and organic cold molded products, it appeared that materials made under this inorganic cold molded process were destined to fill the gap in the electrical wiring devices and other industries between the low melting hot molded shellac materials and the fragile porcelain.

But as the organic cold molded materials presented such distinct advantages over the inorganic products, the general interest to develop inorganic cold molded plastic materials dropped suddenly and manufacturers began to turn their attention towards the newer art of organic cold molding with the result that not much interest was further given to the development of the inorganic products, which at one time promised to become a potent factor in the molded insulation field.

Regardless of the fact that most molded parts previously made of inorganic cold molded compounds were gradually substituted by Hemming's cold molding methods (Class B), and in some cases by Baekeland's process (Class A), a large field of application and uses still remained for materials embodying the characteristics of this Class D.

These molded materials have characteristics and advantages which none of the products of the other classes can replace or substitute and therefore they must be considered vital for application as insulations in the electrical art, especially where heat requirements of over 500 deg. F. are necessary and where no materials with organic binder can be used on account of their not withstanding the actions of the electric arc.

As binders for this class of products, a great variety of cementing materials is employed. It is of utmost importance that a binder which will become a suitable plastic in compounding with the other ingredients be chosen, for on the plasticity of the binder depends the moldability of the mixture to be formed to any desired shape in steel molds under pressure. If the binder or conditions of the molding mixture are not nearly perfect for this purpose no properly molded parts can be derived therefrom.

There are no other known commercial molding materials wherein the molding into difficult shapes is so critical as in the cold molded inorganic process and only few manufacturers, highly skilled in this art, have succeeded in molding such products commercially with success. Credit is due to L. Barringer for much research work to develop the plasticity and molding features of inorganic cements to produce highly important insulation products of rather complicated shapes and forms of materials of this class for use in the electrical field.

Probably the first product of this class to be used in the electrical industry was Portland cement, mixed with water and asbestos, made into laminated sheets under the same manufacturing methods as used in the paper making industry. This was the so-called asbestos cement sheet material, used extensively both in this country and Europe, primarily for roofing purposes. However, it found quite an application

for high heat and arc proof uses in the electrical field, as substitute for slate and for arc separators, etc. Owing to its methods of production, being a laminated material and only so producible in sheet form, this asbestos cement material was later produced under a molding process, the asbestos-water-Portland or magnesite-cement mixture being conveyed to molds up to 3 x 6 ft. in size, and even larger. This mixture was compressed by means of heavy hydraulic pressure, the bottom mold plunger being so constructed as to allow the filtering off of the excess water.

Molded asbestos-cement sheets of almost any size and thickness are so obtained and sheets made by this method have found use in the electrical field in this country as substitute for marble, slate, vulcanized fiber, hard rubber, etc. Such asbestos-cement products are best known under the trade names of "Asbestos Wood" and "Hemit." For purposes where this material is not adaptable due to its water absorbing features, these products are impregnated under heat in open vessels or by means of vacuum and pressure, with hot solutions of pitch, asphalt, paraffin or wax compounds, which fill the open pores and water-repellant insulating mass. Such impregnated asbestos-cement sheet materials are serviceable for a greater variety of electrical purposes but must not be used where they come in contact with the electric arc.

In producing shaped molded articles of this class, the method of molding sheet material is followed, with the exception that the molding mixture must contain much less water as in this case no filtering provisions, other than through the clearance of the mold parts, can practically be made. After the molding operation, the hardening of the molded parts is effected by the action of the hydraulic cement binder, similar to the hardening of concrete.

Magnesia compounds are in some methods substitutes for Portland cement in the producing of such sheets and formed materials, the advantage claimed for the magnesia binder being to obtain sheet materials and molded parts of less hard nature so that they can be much more readily cut, drilled, sawed, or otherwise worked with tools. However, the proportion of Portland cement or magnesia and asbestos used is the vital factor for producing the material in different and desired degrees of hardness. The greater the excess of cement, the harder the resultant product, and the larger the proportion of asbestos fiber, the more readily the material is workable with tools.

In the production of molded sheet and formed articles as described, care must be taken to mold the compounded mixture before the "setting" of the hydraulic binders starts, as otherwise the mechanical strength of the finished product would greatly suffer.

For this reason, in the production of quantity articles, the manufacturers of such molded products prefer to use calcium or magnesium oxides or hydrates as suitable binding cements with fine silica and asbestos fiber, the lime and silica combining after molding, by treatment under steam pressure to a silica-lime cement, the asbestos furnishing the mechanical strengthening structure. The principle of this method is analogous to that of producing silica-lime bricks as fully described under

the chapter on hydraulic cements in this book. Such molding mixtures, by making provision for the retention of moisture required in their compounding, keep their plastic conditions longer than those made with the Portland cement and so make them obviously a more practical proposition, particularly since they can be stored for days and weeks before being molded. While silica-lime cements are better plastics than the Portland cement mixtures, the finished products do not quite stand up to as high temperature as those with Portland cement as binder.

Molded materials of this class are of white or gray appearance, depending partly on the white or gray color of asbestos and also on the use of Portland cement (grayish) or silica lime or magnesia (white) binder.

Materials of this inorganic cold molded class, when impregnated to be rendered less hygroscopic and to improve their dielectric properties are changed to the color of the impregnating compounds which are usually black.

CLASS E—CERAMICS (PORCELAIN, LAVA)

The most familiar representative of this class is porcelain. The other materials are glass, fused silica, fused clay, and soapstone (Lavite).

Porcelain. The porcelain which has found wide and important application for electrical insulation is that variety known as "hard" porcelain. This comprises a large percentage of China clay, to which is added quartz and feldspar or other flux, and sometimes small percentages of gypsum, chalk, etc. The quality of the China clay used is of first importance, for on this is dependent the plasticity of the mixture, which enables it to be molded in the desired forms, and also, to a large extent, the final hardness, strength, and heat-resisting qualities of the product. The proportions in which these ingredients are used vary with different manufacturers, each of whom has developed a formula by which proper results can be obtained. Great care is necessary in each step of the manufacturing process, from the mixing of the ingredients to the annealing of the products as they come from the kiln. Any slight relaxation of care at any one stage is more likely to endanger the quality of porcelain than that of any other molded insulating product.

In the manufacture of porcelain the various raw materials in proper proportion are mixed in rotating drums in the form of a slurry, it being, of course, essential that the ingredients be in a finely divided form, and in the case of the China clay, free from impurities. The excess water is removed by proper filtering methods and the wet mass is stored for some time during which the homogeneity and plasticity are improved. In the dry molding process this plastic mass is dried, re-ground, mixed with water, and molded. In pressing porcelain pieces, more especially when the walls are thin, great care must be exerted. The articles, after drying, are burned in kilns at various temperatures up to 2000 deg. C. The temperatures and methods of firing vary with the different manufacturers, and great skill has been developed at this stage.

Owing to the considerable shrinkage of porcelain in the firing process, it is evident that wide practical knowledge of the behavior of the various shapes in the kilns is essential in order that the final product

shall be of the form and dimensions originally designed, and it is worthy of remark that this art has undergone such development as to render possible the production of parts of very complicated design.

The use of electrical porcelain has lost considerable ground in the last twenty years due to its replacement by other molded plastic insulators, but owing to its lower cost of production, its high voltage resisting, and (in glazed condition) its absolute non-hygroscopic properties, porcelain insulators have proven indispensable, as no other molded materials can favorably compare with it in such characteristics.

Very few developments in the nature of research work and improvements in the producing of electrical porcelain for low voltage uses have been made in this country for the last twenty years, while in regard to porcelain to be used for high voltage insulators, considerable progress was made and our domestic porcelain high voltage insulators are equal if not superior to-day to those of foreign manufacture.

This, however, is not the case with the extensively used low tension porcelain insulators. For the last ten or twenty years, the manufacturers have neither changed nor improved their methods of production to any marked degree. Some radical steps were taken by the more progressive porcelain makers to the extent of abandoning the old kiln fusing method for new and more highly efficient kiln systems. Otherwise, their methods are antique, and no one concern seems to take the initiative of improving them with the consequence that our domestic low voltage porcelain to-day does not reach the standard of accuracy of the foreign products.

The author has discussed this subject with a number of porcelain manufacturers, but no proper reason was ever advanced why we cannot make porcelain here equally as good or better than abroad. Our molded materials which are produced under Classes A, B, C and D are superior to-day to those manufactured in any other country, and if the manufacturers of molded porcelain in this country would devote as little as one-tenth of the research and development work of that done by the manufacturers of phenol-formaldehyde or cold molded materials, we would have better porcelain to-day.

The manufacturers of hot molded shellac materials and the makers of electrical porcelain have only themselves to blame that their products are being so rapidly replaced by phenol-formaldehyde and cold molded compounds. Why do they not develop and improve their materials and methods as did the others? As the author has stated in his discussion under Class C, that the producing of the higher heat-resisting hot molded shellac materials is only a matter of diligent research and development work, so will he state even more emphatically here, that the electrical porcelain manufacturers have to improve their product. The ceramic technology is well understood and the ceramic chemist or engineer ought to be charged with the study and improvement of this problem. Such work ought to be taken out of the hands of the foremen or work managers whose field of endeavor is production and not composition or molding method development.

The production of more accurate porcelain, of less brittleness, will render its use in the electrical arts more desirable and its substitution

by other molded products will not be as necessary. No electrical engineer wants to replace porcelain, but has to, principally due to the lack of stimulant and progress on the part of the porcelain manufacturer.

Lava. For specific high temperature resisting purposes where the commercially known grade of electrical porcelain would not stand up to particular heat conditions, the ceramic material known under the trade name of "Lava" or "Composition Lava" has found a very favorable introduction in the electrical field within the last fifteen years.

As previously mentioned, in an earlier chapter on ceramics, Lava or Steatite is produced from soapstone burned at a temperature of about 2000 deg. F. The various required shapes are cut or worked out from the soapstone slate to the respective forms which are then burned at a temperature of 2000 deg. F.

Another way of producing Lava insulating parts is to grind the raw material or waste, obtained from the cutting process, to a fine powder adding suitable binders or flux materials to obtain a homogeneous plastic mass; which is subsequently dried, powdered, and then sufficiently moistened to be pressed in steel molds similar to the process of molding porcelain. The molded Lava materials are known as "Composition Lava."

In this country, most Lava insulating parts are produced by the first method while in foreign countries, the molding of Composition Lava has been highly developed. The author predicts that the producing of molded Composition Lava will be a subject of considerable attention and successful further commercial development in this country in the future.

CLASS F—RUBBER COMPOUNDS

Among the various materials employed in the manufacture of molded insulation, rubber is the only product which in itself, without the admixture of a filling or strengthening medium, presents all the desirable qualities of an insulator, combined with the necessary mechanical strength and other requisite physical properties. Its toughness, elasticity and flexibility are not even nearly approached by any other insulating substance known to-day. Therefore, its qualifications as a binder for organic or inorganic fillers are also unsurpassed. The only reason why this excellent insulation as well as binder has been gradually replaced is its high price and inability to stand continuous temperatures of 100 deg. C., or over, even when properly compounded with such heat-resisting fillers as asbestos.

Yet for a great variety of electrical insulation purposes hard rubber molded products are non-replaceable and in mechanical, chemical and other arts, hard rubber has found an additional field of adaptability such as to more than offset what it has lost in the electrical molded insulation industry.

CLASS G—ORGANIC PLASTICS (CELLULOID, CASEIN)

Celluloid. While molded insulating parts are not made of this material to any notable extent, it is nevertheless employed for this

purpose, especially where ornamental appearance is a considerable factor. It is a good insulator and can be molded with greater facility than perhaps any other material, and were it not for its poor heat-resisting qualities, it would be extensively employed for electrical insulating purposes.

Celluloid is a solid solution of more or less nitrated pure cellulose in camphor, and is pressed, after evaporating the various solvents, in the form of sheets, plates, blocks or rods. In this stage it is a transparent, elastic, flexible mass which can be given any desired color by the introduction of dye stuffs or pigments.

Before going into the details of the manufacture of celluloid, the manner of making nitrocellulose and the general method of making celluloid will be briefly outlined.

Nitrocelluloses are celluloses which contain the nitro group NO_2, and are known as Di, Tri, etc., up to hexanitrocellulose or even higher ones, according to their content of the nitro groups. In celluloid manufacture, as a rule, the higher nitrated celluloses are used, commonly known as "gun cotton" which contain about 9% to 12% nitrogen.

They are obtained by treating very pure cellulose, like tissue paper, purified cotton, flax or hemp fibers, with a mixture of concentrated nitric acid and more or less concentrated sulphuric acid.

The proportions of the two acids may be varied considerably. For instance, three volumes of nitric acid Spec. Grav. 1.517, to one of sulf. acid Spec. Grav. 1.84, or three volumes of sulf. acid Spec. Grav. 1.845, to one of nitric acid 1.5, are used.

The proportions of the paper and of the acid mixtures vary considerably. Furthermore, a different time of reaction has to be allowed according to different conditions. The space in this book is too limited to go into these complicated details.

The nitrocellulose, purified by washing with cold water until perfectly free of acid, is then treated with a weak sodium carbonate solution at ordinary temperature, and the latter again removed by washing with cold water. The pure material is ground to pulp, the water extracted in centrifuges, and after having been dried at about 40 deg. C. it is mixed with a solution of camphor in alcohol.

The proportion of camphor and nitrocellulose varies from 20% to 30% of camphor and 70% to 80% of nitrocellulose.

The alcoholic camphor mixture is passed between rollers heated to 105 deg. C. This process is carried on until a homogeneous and plastic mass results. These rolled celluloid sheets are then pressed into solid blocks, free of air bubbles, under a pressure of about 3,500 lbs. per square inch.

A few of the special methods employed in the manufacture of celluloid may be mentioned.

1. The so-called Hyatt process consists in dissolving gun cotton in molten camphor. Satin paper is sprayed with a mixture of two parts nitric acid and five parts sulphuric acid as it is unwound from a roll, whereby the greater part of the paper is converted into nitrocellulose or pyroxylin. The acid is now entirely removed by washing with water,

and the plastic mass is subjected to considerable pressure and dried. The lumps, after being broken up again and drained in a hydro extractor are ground and finally mixed with the camphor in the proportion of one part of camphor to two parts of pyroxylin, though other proportions also give good results.

The well mixed mass is then pressed in order to expel any watery constituents still present; and furthermore, to bring the particles of camphor and pyroxylin into still more intimate contact to facilitate the solvent action of the former.

The dried and pressed mass is placed in molds and given the desired shape by the application of hydraulic pressure, under heat. On leaving the press, the celluloid is hard, but remains plastic and can be re-softened by warmth, or by placing it in boiling water.

2. Cold process of preparing celluloid.

In operating this process, the greatest care must be taken on account of the great inflammability and low boiling point (35 deg. C.) of the ether which is used to dissolve the camphor; thorough ventilation of the factory rooms is very essential. The proportions used in this method are 50 pounds of nitrocellulose, suffused with a mixture of 100 parts of ether. After the ether has been slowly evaporated, the mixture finally becomes a transparent, sticky, gelatinous mass, which is rolled between a pair of superimposed calendering rollers until it is plastic. On exposure to the air, the rolled viscid sheets attain a certain hardness. They are then warmed and subjected to powerful pressure. This is important as the valuable properties of celluloid are improved in proportion to the pressure applied. To obtain good celluloid by the cold ether process it is also highly important that the raw material should be dry and perfectly free from acid, otherwise the celluloid will be cloudy.

3. In another process, the gun cotton after being pulped with water, is treated with a mixture of camphor and woodspirit (methylalcohol). The principle, however, is identical with that of the other process.

Pure celluloid is nearly colorless. In thin sheets it is as clear as common glass. It is very elastic, transparent, tough, and hard. Celluloid has a faint smell of camphor which becomes stronger when the mass is rubbed. It is electrified by friction. Heated sufficiently it becomes plastic and can be molded into any shape desired. On heating up to 140 deg. C., celluloid loses its color and transparency, and at about 50 deg. higher decomposes with the liberation of pungent, readily inflammable vapors.

Since celluloid softens in warm water the molding process is greatly facilitated by this behavior. Celluloid ignites only when brought in direct contact with flame and then burns with a smoky flame giving off an odor of camphor. On blowing out the flame the mass continues to flow and to give off thick fumes of camphor. This is a clear proof that celluloid is not a chemical combination of camphor and gun cotton, since it is characteristic of chemical reactions that the substances entering into combination cease to exist independently in the compound.

Celluloid is insoluble in water and though not immediately attacked by concentrated sulphuric acid it gradually dissolves therein. A small

piece entirely disappears in about 36 hours. Concentrated nitric acid and boiling caustic alkali also gradually dissolve it.

The specific gravity of celluloid varies according to the degree of pressure to which it has been subjected in the manufacture, the mean being 1.50.

Celluloid is very extensively used as a substitute for horn, tortoise shell, coral, malachite, lapis, marble, ebony, amber, caoutchouc, ebonite, etc. As a matter of fact there is hardly any natural product which has not been imitated in celluloid.

Continuous experimenting and research is carried on in attempts to render celluloid less inflammable and to make it more useful as an electrical insulator.

Albumoids-Casein: Plastic products of this class have been described in an earlier chapter of this book. Their use as electrical insulators is restricted to about the same degree as celluloid products. The casein materials, however, are not inflammable and for this reason they are used in the electrical art in preference to celluloid products, yet their drawback is that that are not as absolutely reliable to stand up under water or climatic conditions as hard rubber, which material casein sheet or rod material resembles, both in appearance and ability, to be worked with tools.

Casein products are not made in molded shapes, but have found a very successful application in sheet and rod form for wireless and other electrical appliances. The author foresees its application for many uses in successful replacement of hard rubber and vulcanized fiber.

CLASS H—LAMINATED INSULATIONS

It will be convenient under this head to consider a somewhat varied collection of products related to or made from mica-paper or mica-cloth. R. P. Jackson in the Electrical Journal, 1919, page 330, gives the following list of such materials:

Name	Origin	Method of Manufacture
Linen paper	Linen scrap	Compressed and sized.
Kraft	Wood pulp	Sulphate treatment unsized.
Rope cement paper	Old rope	Compressed and unsized.
Press board	Cotton rags	Compressed and sized.
Fish paper	Cotton rags	Digested sulphuric acid.
Hard fiber	Cotton rags	Digested zinc chloride.
Asbestos paper	Asbestos and cotton fiber	Compressed, unsized.
Asbestos lumber	Asbestos and hydraulic cement	Compressed, unsized.
Asbestos board	Asbestos and water-glass	Compressed and heated.
Paper micarta	Kraft paper and shellac or bakelite	Compressed and heated.
Duck micarta	Cotton duck and bakelite	Compressed and heated.

Paper, which is used especially in condensers and coil winding, may be either untreated, that is, consumed as it comes from the paper machine, or it may be more or less completely "parchmentized" by digestion with sulphuric acid or zinc chloride solution; or yet again, the paper may receive special treatment, such as a coating with varnish or mica flakes and varnish. Some of such products are known as Micarta, in particular, Paper-micarta, as distinguished from Cloth-micarta, similarly made from cloth. The varnish may be of shellac or synthetic resin base.

Such micarta materials when made of fibrous materials such as paper, duck, muslin, etc., with synthetic resinous binders, are very stable and exhibit high dielectric, heat-resisting and water-repellent qualities; and as a principal feature, have a most extraordinary mechanical and tensile strength.

When the binders are of a natural resinous nature, the heat-resisting properties are governed by the softening point of the binder, but when phenol-formaldehyde binders are used the fibrous material is the factor governing resistance to heat.

Molded mica is made by splitting mica into thin laminæ which are cemented together by means of resinous binders, principally shellac. The so built-up sheets or forms are afterwards subjected to pressure and heat, the heat melting the binding materials and forming a compact product. According to the nature and proportion of the binders used, these mica compositions can be made more or less heat-resisting, but obviously to such a degree only as the binding material will withstand.

All attempts so far to cement mica in sheets or in powdered form by means of an inorganic binder have failed, but should these attempts eventually prove successful, a very broad, new field will be opened up on account of the excellent electric properties of mica.

The materials which the author brings together under the term "Laminated Insulation" are not strictly to be termed "*Molded* Insulators." With the exception of mica perhaps, which in laminated form is molded into quite intricate shapes in heated molds, most of the products of this class are formed and then pressed by various means. The principal products obtained from materials of this class are tubes, rods, and sheets. With phenol-formaldehyde binders, such shapes as valve discs, gears, and pinions are made.

The laminated products as are of interest to this chapter may be best subdivided into the following characteristic groups:

Group 1. Synthetic Laminated Insulation made of paper or cloth products, cemented with phenol-formaldehyde binders. Micarta. Bakelite-Micarta. Bakelite-Dilecto. Formica. etc., are trade names for such products.

Group 2. Vulcanized Fiber.

Group 3. Molded Mica products.

Group 4. Pressed Hard Paper, such as "Papier-Maché" Presspan, Pilit, Leatheroid.

CHAPTER IV

MOLDS AND DIES

In the molded insulating trade these terms are synonymous.

Most electrical engineers are familiar with some methods employed in the construction and operation of the molds in general use in the manufacture of insulating parts. The molds play a very vital part in such manufacture and are often the cause of serious difficulty to the manufacturer, and consequent misunderstanding between him and his customer. The author will as briefly and comprehensively as possible sketch the more important factors in their construction and use, to enable the user, through a better understanding of their operation, to avoid those elements of design which tend to complicate manufacturing operations. This knowledge will facilitate the selection of forms for his insulating parts which, while rendering them no less effective for his purposes, will enable the manufacturer to produce pieces of minimum cost, maximum efficiency and neat appearance.

Frequently designers, when bringing out new forms, insist on having dies of the cheapest construction made in order to get out a few sample pieces. This results in serious trouble for the manufacturer, and dissatisfaction for the customer until a proper mold is substituted.

This is especially true when the form of the piece is in any way complicated by holes, projections, or irregular surfaces, and unless the molds are made of the very best steel, and all the parts come together with a perfect fit, the molded pieces will be more or less misshapen and have burrs or fins on their edges. These imperfections are a frequent cause of complaint. It is, therefore, very important to have the molds of such quality that they will wear for as long a time as possible without producing pieces with these defects. All dies will eventually wear out, and the only remedy then is to replace the worn parts or make complete new dies.

The form of the piece and the character of the material to be molded play an important part in this particular, and a mold may show more wear after a run of 10,000 pieces of one material than it would after turning out 100,000 pieces of another material.

TYPES OF MOLDS OR DIES USED IN THE MANUFACTURE OF MOLDED INSULATION

There are two different classes of dies in general use. They are known as "OPEN DIES" and "CLOSED DIES."

The term "OPEN" is applied to that class of dies or molds which

are composed essentially of two flat pieces in one or both of which a recess is provided to hold the material to be molded. In operation, these plates come together at a cutting edge which chops off the excess of material which has been squeezed out of the recess containing the molded part.

The term "CLOSED" is applied to that class of dies or molds which are composed essentially of a plunger and a box. In operation, just enough material to form the part is placed in the box; the plunger then enters the box and forces the material to all parts of the mold. In practice these dies are made with two plungers; the upper plunger, which, generally speaking, does the compressing; and the lower plunger, which forms the bottom of the mold, and which, after the piece is formed, raises to push the piece from the mold.

Both "OPEN" and "CLOSED" dies are in general use for the manufacture of hot molded materials, while only closed dies are employed in the manufacture of cold molded products.

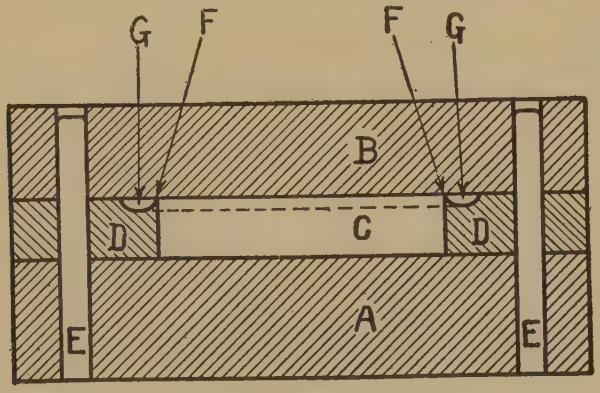


FIG. 1

Figure 1 represents an open die, such as is used in the manufacture of materials of Classes C, F, G and H, when such materials are prepared in sheet or cake form and placed between the compressing plates in a warm or plastic condition.

This die, which is intended to produce a disc or short cylinder having parallel sides, is made in three parts, the Bottom Plate "A," to which is screwed or otherwise fastened the middle plate "D," containing the opening "C," in which the piece is to be formed, and the top Plate "B," which closes the die, guided by the pins "E."

In operation the die is heated; an excess of material is placed in the cavity "C;" the die is closed; the Cutting Edge "F" cuts off the surplus material, which has been squeezed into the depression "G" formed to receive it. The die is then cooled and opened; the plate "D" is released from the plate "A," and the finished piece is pushed out by the fingers or other means.

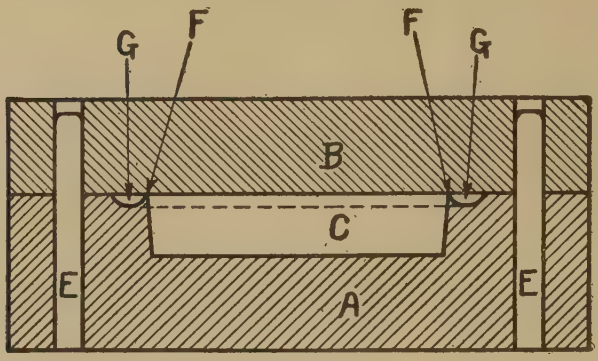


FIG. 2.

If the sides of the piece instead of being straight are tapered, a simpler form of mold shown in Figure 2 can be used.

In this case, the die can be made in two parts, and after the piece is formed and the die cooled, the piece, due to its tapered form and the shrinkage incidental to cooling, can be readily removed by simply inverting the die and rapping it till the piece falls out.

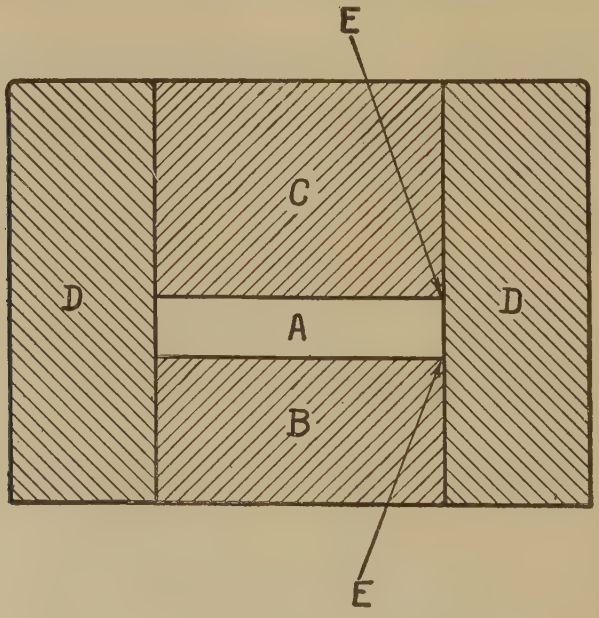


FIG. 3

In Figure 3 is shown a closed die, such as is used in the molding of materials in a heated state and comprises a Box "D," an Upper

Piston "C," and a Lower Piston "B," having between them a cavity "A" in which the piece is formed. It will be noticed that the upper piston is longer than the lower one.

In operation the Box "D," with the Lower Piston "B" is placed upon a heated press table and the material to be pressed is placed in the Cavity "A," see Figure 4. Before pressing, this material occupies a volume considerably greater than the volume of the finished piece, and for this reason the Top Piston must be longer than the Bottom Piston, since it must travel into the box a sufficient distance to compress the material to be molded to the required density.

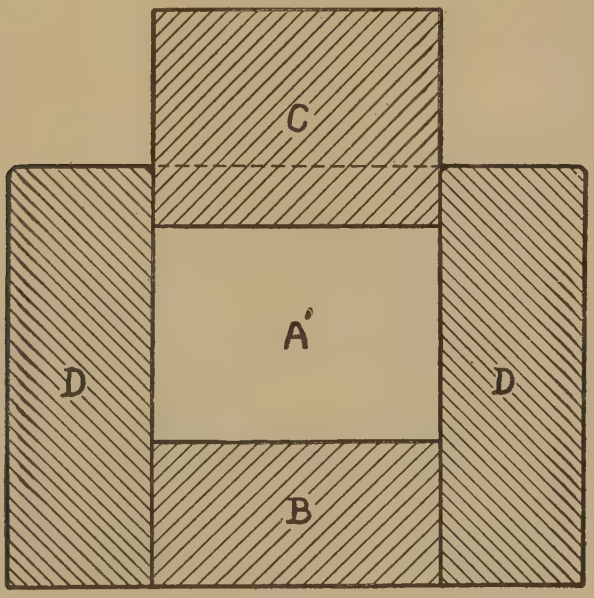


FIG. 4

The Top Piston is now placed in the Box and the Upper Platen of the press, which is also heated, is brought down by hydraulic or other pressure on the Piston "C" until its top surface is flush with the top of the Box "D." The die is now held between the heated plates of the press until the material in the Cavity "A" is melted. The steam is then shut off and cold water is run through the plates of the press until the material in Cavity "A" is sufficiently cooled to render it hard enough to permit of its removal from the mold.

Sometimes the walls of the Box "D" are provided with channels through which the steam and water are run to expedite the molding process.

In practice, steam is kept on the press plates and molds just a sufficient length of time to properly melt the material to be molded,

and the water is run through only long enough to permit of the ready removal of the finished piece, as the time consumed in these operations determines the output of the press, and so directly affects the cost of the piece. In making parts, such as bushings and other pieces having holes in them, which are formed by pins incorporated in the mold, the piece must be removed from the die before the shrinkage has progressed to a point where the material would seize upon the pins and thus prevent its easy removal from the mold.

It is necessary that the Pistons "B" and "C" should be a nice fit in the Box "D" in order that the pieces may come from the dies without burrs, which would otherwise form at "E," Figure 3. It is obvious, however, that constant use will eventually cause the box and plunger to wear, when the mold will necessarily produce defective pieces.

This type of die may be used for molding any class of material, but is usually employed in the hot molding of such materials as those of Classes C, F, G and H.

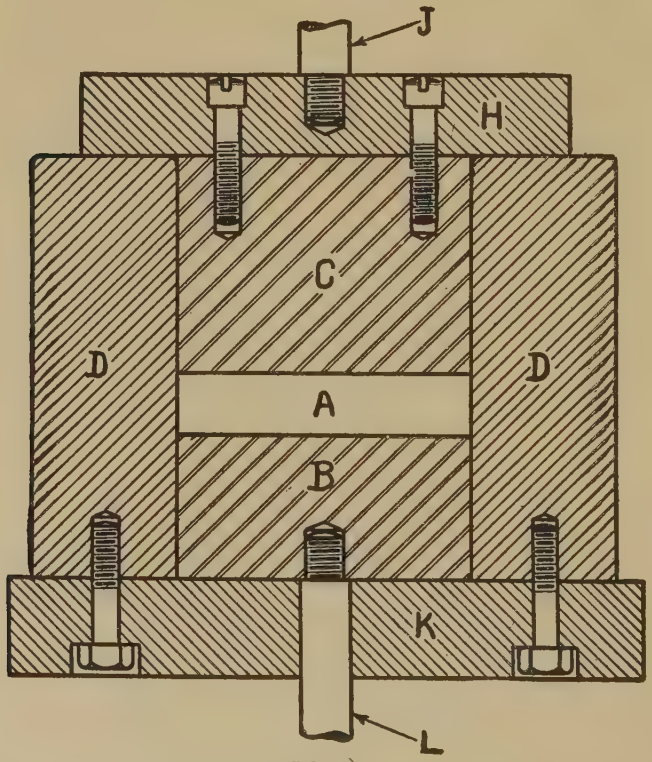


FIG. 5

Figure 5 shows a die of the type used in the manufacture of molded materials, such as those of Classes A, B, D and E. This die

embodies the same general principles as those shown in Figure 3, but in this case, the Upper Piston "C" is attached to the Plate "H," which in turn is attached to the upper platen of the press. The Box "D" is attached to a Plate "K," which is fastened to the bed of the press and the lower piston is operated by means of the Throw-out Rod "L" connected to the lower plunger of the press.

The operation is as follows:

The mold is filled with the material to be pressed as in the case of Figure 3, and the piece is compressed in a similar manner. At this point the similarity ceases. After the piece is pressed, the Upper Piston "C" is withdrawn from the mold and the Lower Piston "B" is raised by the Throw-out Rod "L," and by this means the piece is expelled from the mold. The Piston "B" now descends to its normal position at the bottom of the mold and it is then ready for re-filling without having to undergo any heating or cooling operations.

When dies of this type are employed, the materials are either weighed or measured beforehand, and just sufficient is introduced into the die to form the piece.

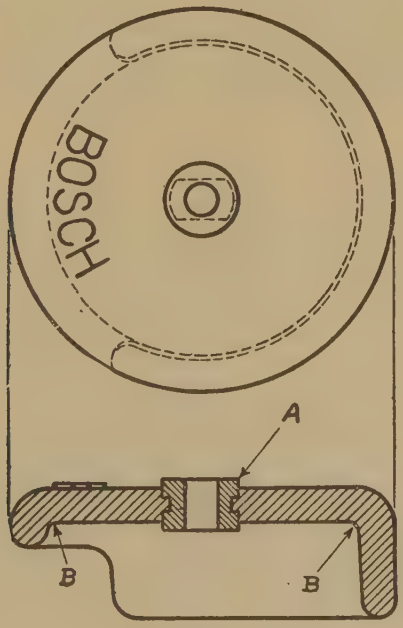


FIG 6

Figure 6 shows a molded piece with a metallic insert "A" molded in. Such pieces can be easily produced in materials of Classes A, B, C, D, F and G. However, if absolute accuracy, together with a highly polished piece is required only Classes A, C, F and G can be considered. Class B could be advantageously molded into this shape, but a slight

variation must be tolerated and only the exterior surface can be polished. Class D could be molded, but it would be necessary to increase the radius at "B" as much as possible.

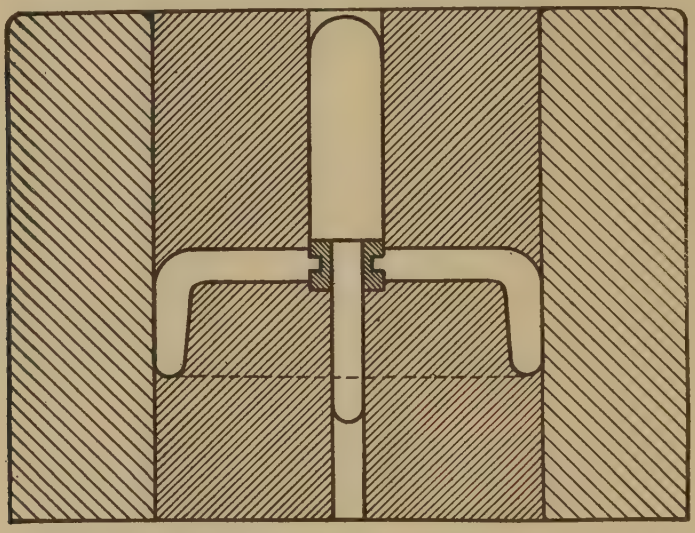


FIG. 7

Figure 7 shows the design of the mold from which this piece is produced, and is here represented to illustrate the manner in which inserts are molded into the materials. These inserts should be provided either with a knurled or some other rough and irregular surface so that they may be firmly gripped by the material.

Another point of interest is the production of letters or figures on molded pieces.

On materials such as those of Classes A, C, F and G, where the pieces come from the molds in a polished condition, no difficulty is experienced in producing raised letters. However, if such materials as those of Classes B and D are used, where the pressed pieces do not come from the molds in a finished condition, but must be hardened, and polished, raised lettering cannot be used, as the polishing of the surface would destroy them. Therefore, it is essential in all cases where pieces are to be made of materials in Classes B and D, that the designer employ some other means to incorporate the lettering on his pieces.

An excellent method and one which has became a standard for use in connection with these materials is to recess a portion of the surface, leaving the letters raised and flush with the main surface, so that the tops of letters receive the same polish as the rest of the surface.

Metal inserts are never molded in pieces made of the ceramic materials. Openings or recesses are molded, into which the metal parts are inserted and held in place by riveting or other mechanical means.

Usually sealing wax or some other form of cement is used to fill the recesses, covering the screw heads or nuts to prevent the exposure of live parts.

Figure 8 shows a typical cross section of a molded insulating box or cover, and illustrates very nicely some of those elements of design constituting a part of that unwelcome legacy which comes to the molded insulation manufacturer from his predecessors who worked with materials of a very different nature.

This cross section shows a cover or box having thin walls and sharp interior corners. In other words, a typical metal box or cover, which offers no difficulty whatever to the metal stamper, but which is not well adapted to meet the requirements of the modern molded insulating materials; it is a good, if very simple, example of the trouble designers

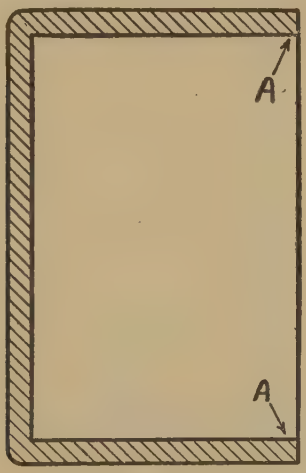


FIG. 8

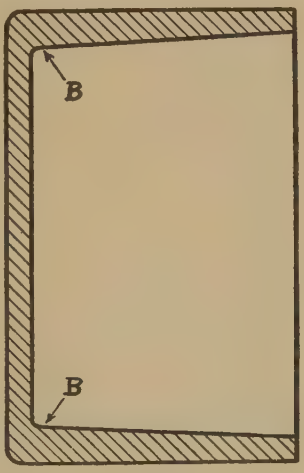


FIG. 9

often make for themselves and the molded insulation manufacturer by failing to bear in mind that the characteristics of modern materials differ from those formerly in common use. If, as often happens, the apparatus, of which this cover is to form a part has been made, or the component metal parts which compose it are already under construction or ordered from some other sources before the molded insulation manufacturer is consulted, the designer of such a cover may find himself in trouble and be fortunate if he has put himself to no greater inconvenience than to greatly restrict the number of materials from which this part can be made.

The design of this cover, Figure 8, is entirely unsuited for manufacture from materials of Classes B, D and E, which are among the practical materials from which to make such parts as switch and fuse box covers, owing to their high heat-resisting qualities, but the straight thin sides of the box practically make it impossible to form this piece of these materials, and it would be very difficult to properly mold the

thin parallel sides, as the material would not be compactly pressed at the top of the sides, point "A," unless a complicated mold were employed, which would exert the necessary extra pressure.

Should there be room inside the box to thicken the side walls particularly at their base point "B" Figure 9, and so give the sides a taper or draw, the design would be improved. Even this added thickness is not sufficient in most cases, as it would be of great advantage to put as large a radius as possible in the corners "C," as is shown in Figure 10.

Figure 11 shows a cover having the proper thickness of walls, with the necessary draw or taper to the inside, and a generous fillet or curve in the corners to make it an ideal design for the proper flowing and molding of the materials of Classes B, D and E. This form is equally

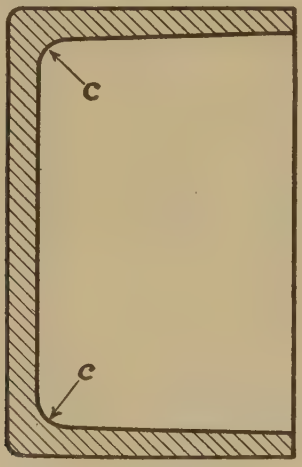


FIG. 10

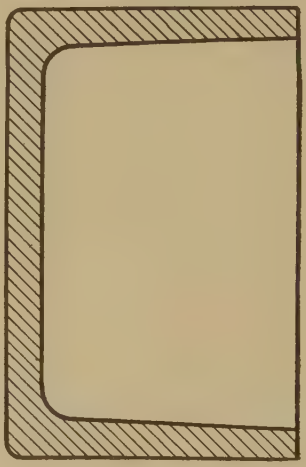


FIG. 11

well suited to materials of Classes A, C, F and G, although the free flowing qualities of these materials do not make it imperative that the piece be designed in this manner.

Figure 12 shows a receptacle box of rather intricate form. Formerly such pieces were made exclusively in porcelain, but are now also extensively manufactured in the cold molded materials of Class B.

The synthetic resinous materials of Class A are splendidly adapted to producing pieces of this character, but they are very rarely used because of their high cost in comparison with Classes B and E.

In the previous illustration, particular stress has been laid on the desirability of designing such pieces with thick walls and ample radius at the bottom, particularly when made of materials in Classes B and E. Too much emphasis cannot be laid on these points.

Figure 12 shows that it is possible to produce pieces of this design in these materials, but it is not accomplished without some difficulty, and in some cases it requires a very complicated mold. It also becomes

necessary to sacrifice the mechanical strength in order to have a mixture of material which has the viscosity necessary to meet the molding requirements.

A much more satisfactory design for both the customer and manu-

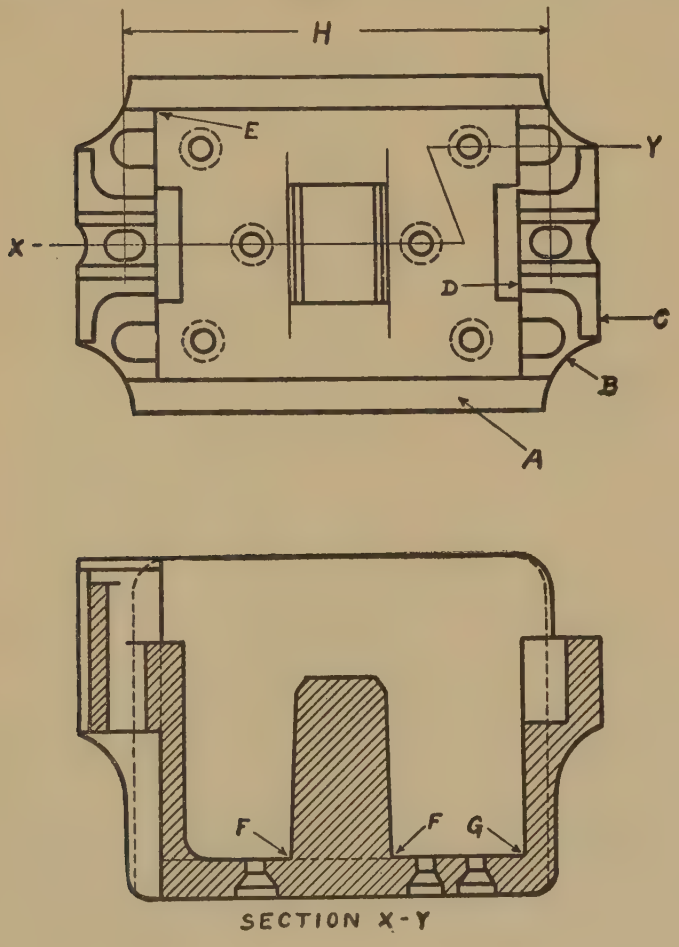


FIG. 12

facturer would have resulted if walls "A," "B," "C" and "D" were made somewhat thicker; also by the addition of a radius at points "E," "F" and "G."

In folding pieces of this character in porcelain, it has been the custom to allow for a variation in the distance "H" by making the holes about $\frac{1}{32}$" larger than the diameter of the screws which fit in these holes.

Although the manufacturers of materials of Class B generally claim

that they can mold such pieces more accurately than those made in porcelain, it would be advisable for the designer not to figure on absolute accuracy in a piece of this nature, if he intends to have them made of this material. He should allow for a few thousandths of an inch variation.

Designers frequently assert that they are limited as to space, both

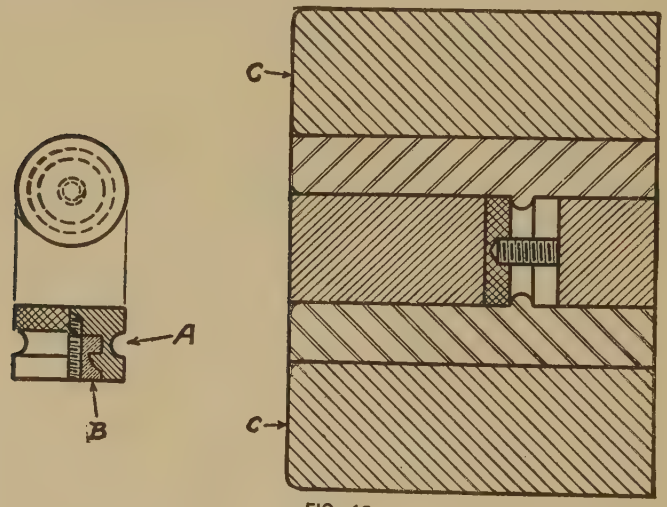


FIG. 13

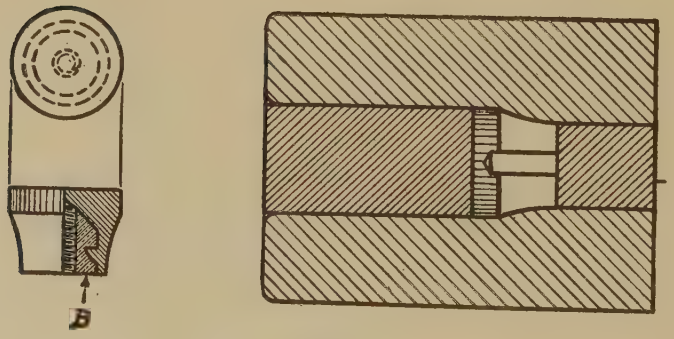


FIG. 14

inside and outside, of such parts, but, with a better understanding of the fundamental requirements of the molding art, and a fuller realization of the difficulties they make for the insulation manufacturer, and the consequent higher cost and poorer quality of the pieces they obtain, they can originate pieces better adapted to molding in the materials they require.

By giving a little more consideration to the molded insulating parts

before the design of the apparatus, in which those parts are to be incorporated, has become irrevocably fixed, designers would materially help themselves as well as the insulating manufacturer.

Figures 13 and 14 show two insulated knurls of different design, serving the same purpose, and the molds for producing them.

Figure 13 shows the original or incorrect design and Figure 14 the same piece altered to facilitate the molding, increase the production, improve the appearance of the piece, and to make the mold much easier and less complicated to manufacture and handle.

The piece shown in Figure 13 presents numerous difficulties. The groove "A" on the side and also this type of knurling makes it absolutely necessary for the piece to be surrounded by a number of loose parts which must be removed from the Box "C" in order to free the piece from the same. This can readily be seen from the section shown. At the junction of these loose parts, a fin or burr will be formed which must be removed, thus increasing the cost of manufacture and affecting the appearance of the piece.

Another bad feature of this design is the thread molded in the material above the metal insert "B." As all molded insulating materials shrink more or less, the threads in the molded material will be smaller than those in the insert.

On the other hand, the design as shown in Figure 14 is much simpler and less complicated. The groove on the side is entirely eliminated and the style of knurling is changed from braided to straight, thus making it possible to push the piece from the mold by merely pressing it from the bottom towards the top. This, of course, does away with the loose parts and eliminates all burrs and produces a perfectly clean, smooth, and neat appearing piece.

It will also be noticed in this figure that the insert "B" has been lengthened to accommodate the full depth of thread which would otherwise be partly molded in the material. The sloping sides or pointed appearance on the end is to allow the material to flow off and around it instead of packing tightly and crushing on the top as it would do if it were flat.

Therefore, the design as shown in Figure 14 is strongly recommended whenever it is possible for two important reasons:

First: The lower cost of production.

Second: The freedom from burrs which will form at the junction of the split portions of the mold made necessary by the groove on the side, and the use of this type of knurling.

These conditions apply not only to insulated knurls, but to any pieces of similar design or construction.

Figure 15 represents a molded base with a projection "A" and numerous counterbored holes. A piece of this design is readily molded of the hot molded materials, Classes A, C, F and G, also of the ceramic materials, Class D. It can also be molded of materials of Classes B and D, if certain changes in design are made.

In the first place the flowing qualities of these materials, Classes B and D, make it difficult to mold such shapes as projection "A,"

unless molds of complicated construction are resorted to. Such pieces can be made perfectly practical for cold molding by the introduction of two simple modifications.

First by the addition of a radius around the base, as is shown at "B" in Figure 16, and secondly by giving a slight draw or taper to the sides, which is also shown in this same figure.

With these modifications, such a projection can be readily molded true in form, neat in appearance, and with the proper mechanical strength.

It is possible to mold pieces with this projection exactly as is shown

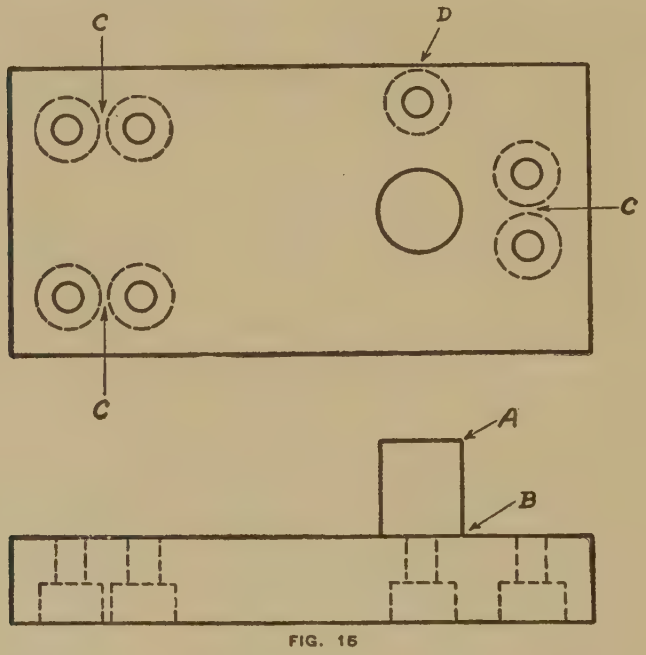


FIG. 15

in Figure 15, but the modifications suggested are simply to increase production and to reduce the cost.

Another point is the shape of the counterbores. In Figure 15, two counterbores are shown which are so close together as to leave a very thin separating wall, as at point "C." At point "D" there is also a very thin wall produced between a single counterbore and the side of the piece. When wood and fiber were extensively used and insulating pieces were machined from blocks and sheets, this was a logical design, but it is not now well suited to the peculiarities of modern insulating mediums.

In order to adapt this piece to the present requirements of cold molded materials, it would be advisable to eliminate these thin walls by cutting them away, as is shown in Figure 16, thus making one

elongated counterbore, and opening the other to the outside of the piece.

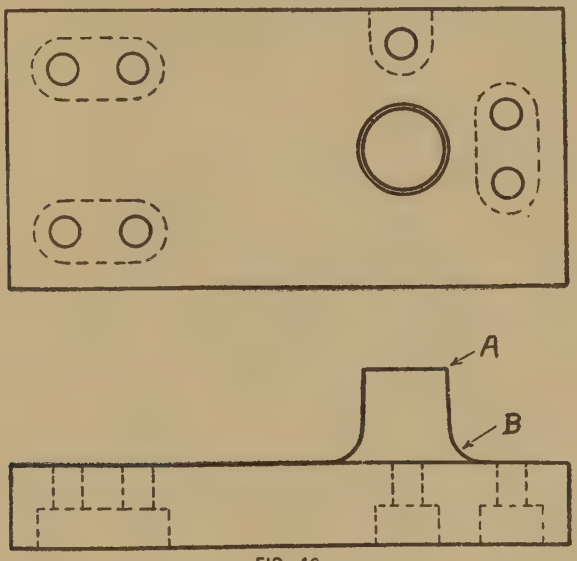


FIG. 16

If, however, it be necessary to have a barrier of this kind separating these counterbores owing to electrical requirements, the designer should place these holes far enough apart and away from the edge of the insulating piece so as to allow a wall of ample thickness.

In all cases, the depth of the counterbores should be no greater than the requirements of the piece, and ample draw or taper should be allowed on the sides of the same in order to allow the easy removal of the piece from the surface of the pistons in the mold.

All holes should be made as large as convenient for their purpose, so that the pins in the mold which form them may be as rugged as possible.

Figure 17 is a typical piece of molded insulation used as a strain insulator in overhead line construction and shows how the insulating material is molded around the metal parts.

The hot molded materials of Classes A, C and F are well suited to the manufacture of such parts, and while formerly the rubber compounds of Class F were extensively used, to-day the materials of Class C practically monopolize this field, chiefly on account of their lower cost.

For this latter reason the synthetic resinous products of Class A have not come in use for such purposes, their cost being too high, although this material would stand up well as an insulator under the severe climatic conditions to which such insulators are exposed.

The cold molded materials of Class B are used for the manufacture

of such pieces, but to a limited extent. As they do not possess the necessary plasticity to be molded as easily as the hot molded products, the molding of such parts causes difficulties owing to the high pressure required to obtain perfect molded pieces.

The hot molded materials of Classes C and F are readily molded

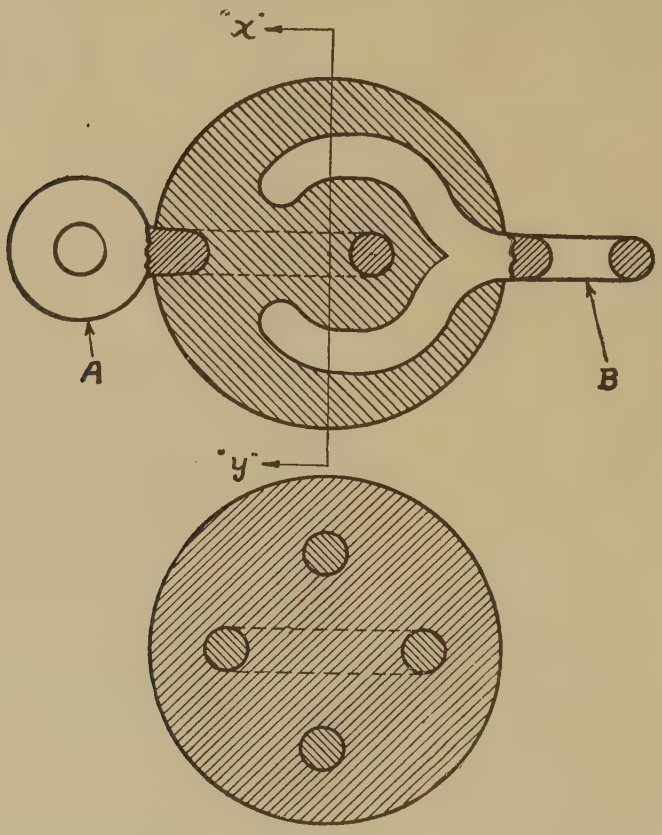


FIG 17

with comparatively little pressure while in a hot plastic condition around the two metal parts which are held in position at the outer ends by the die.

In case of molding materials of less plastic nature such as Class B around these two metal parts, such materials do not flow easily around the metal inserts, but have to be forced around them by means of high pressure. These inserts, held in position only by the die at their extremities "A" and "B," and having no central support, are apt to be distorted, rendering the finished piece imperfect and useless for service.

The Figure 18 illustrates a magneto insulator as is commonly used for automobile work. Formerly such parts were made either of materials of the rubber compounds of Class F or else of special grade materials of the organic hot molded products of Class C.

As the magnetos are usually placed near the hot engines, and the insulating parts come in contact with hot oils and gasoline vapors,

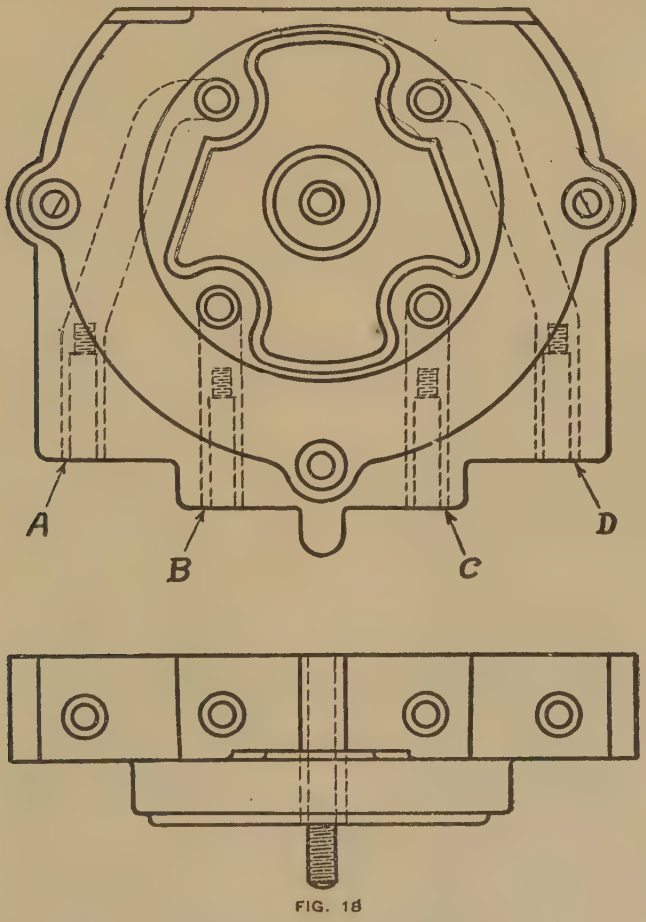


FIG. 18

considerable trouble was previously experienced with the materials above mentioned for parts of this nature. This trouble was caused by either the materials not being heatproof enough or else by being affected by the oil and gasoline vapors.

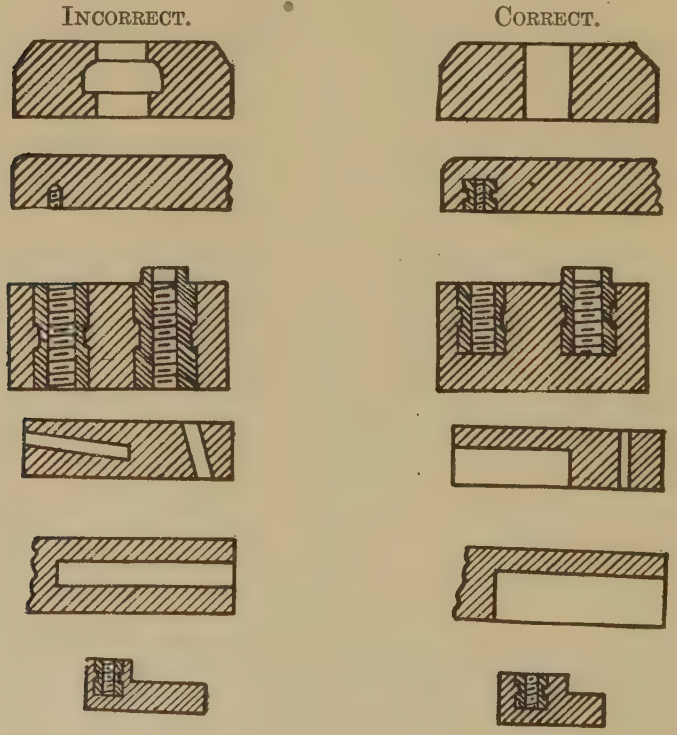
The materials of Class B could not be molded accurately enough, and they are primarily adaptable for use under working conditions below 1,000 volts. The products best suited for such parts and

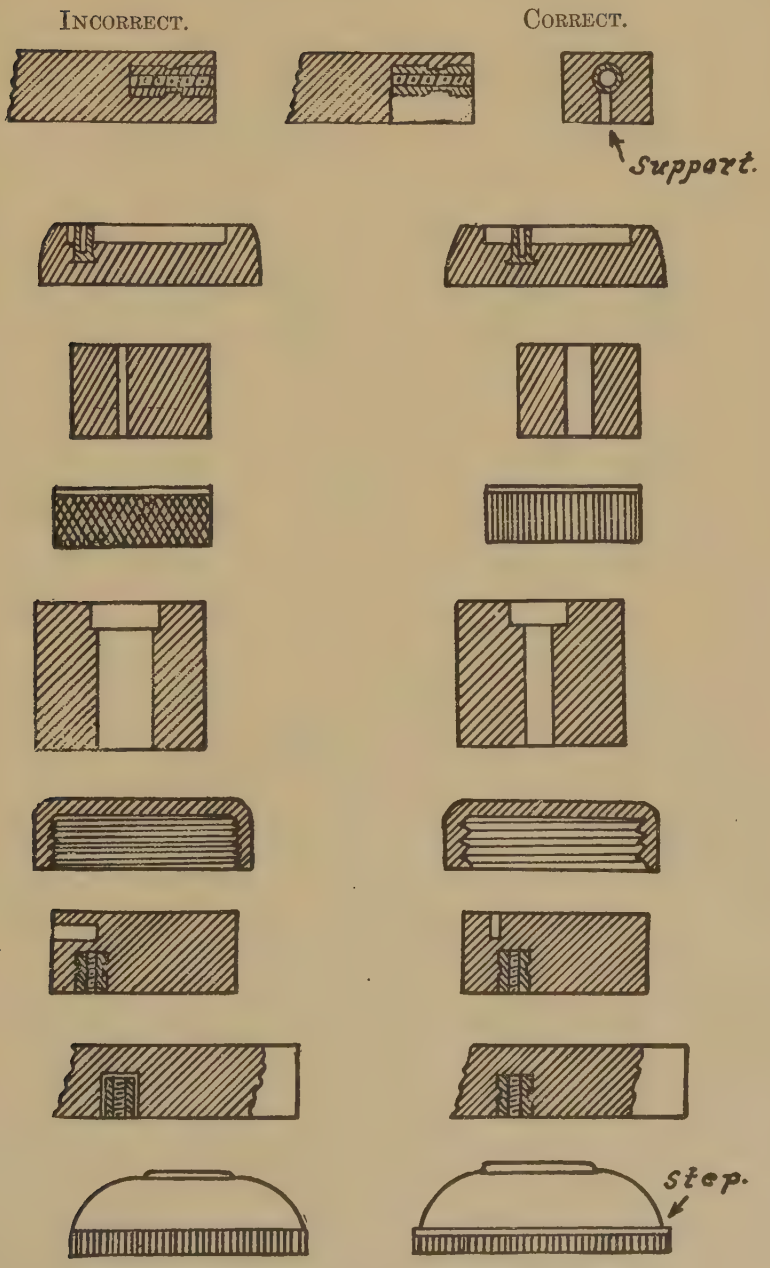
which fulfill *all* the requirements are the materials of Class A. These materials are already almost entirely employed for such purposes.

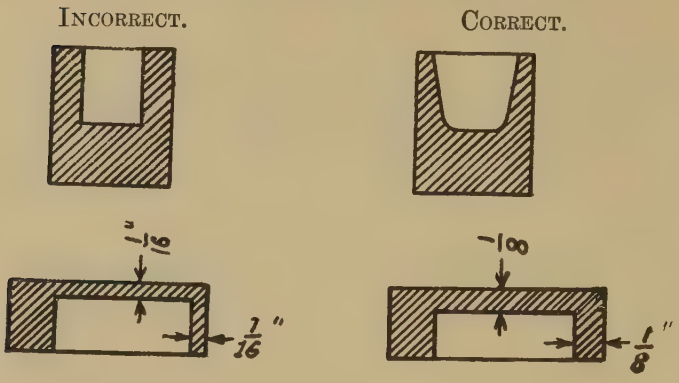
In the molding of such shapes of materials of Classes B and D, the four inserts A, B, C and D would present some difficulties owing to the high pressure required in the pressing. These inserts, as shown in Figure 18, can only be supported at their extremities, and there would be great danger of their distorting between the supporting points.

Therefore, the principal feature to bear in mind is the position and shape of the inserts, and that they be designed and located so that they may be easily and firmly held in position and sufficiently supported so that they will not bend or distort during the molding process.

The following sketches will indicate further some factors to be considered in the design of molded parts. On the left hand side is indicated the incorrect and on the right hand side the corresponding correct design, from the molding point of view.




Incorrect.
Correct.
Support.
Step.


INCORRECT.
CORRECT.
1/16"
1/8"

CHAPTER V

SELECTION OF MATERIALS IN RELATION TO DESIGN AND USES OF INSULATING PARTS

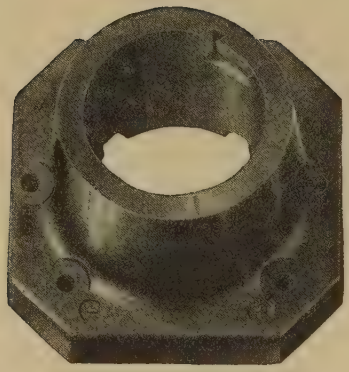
The molding, physical, mechanical, electrical, and other properties of the different classes of materials, as they affect their relative adaptability to the production of various molded articles, have been treated in previous chapters. This question is, however, of such vital importance to the designer and electrical engineer that the author has thought it advisable to offer some further suggestions, aided by illustrations, which, it is hoped, will prove helpful to those having to select the material best suited to their purpose from among the classes treated in this work. Since entirely legitimate differences of opinion must exist as to what may be required of an insulating material for a given purpose, these suggestions are evidently not offered as final or as applying to every circumstance that may arise.

The author's long and intimate experience in manufacturing materials of all of the classes treated, as well as his personal and business relations with the foremost electrical designers and engineers, permitting him, as they do, to base these suggestions on the experience of the past twenty years both in the laboratory and in actual service, leads him to believe that they will be of some assistance to those seeking information.

PLATE I

PLATE I

Familiar radio insulating parts shown here can be molded from materials of Classes A, B, C, F, or G. However, it has been found that the insulation of Classes A or F is best suited since the dielectric properties of phenol-formaldehyde and hard rubber give most satisfactory results for this class of radio work.



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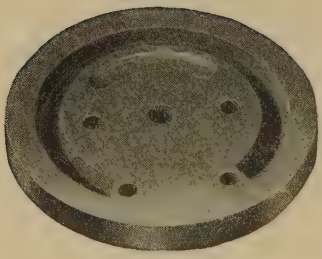

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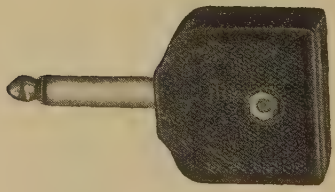

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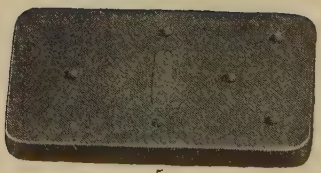

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PLATE II

PLATE II

For these radio parts, materials of Classes A, B, C, F, or G can be used. Those of Classes A or F are best for appearance, while products of Class B are less costly and serve the purpose equally as well. For this reason, most of such parts are made of cold molded insulation, Class B, with the exception of dials, Figure 2, and knobs, Figure 6, which are produced chiefly of materials of Classes A, C, and F, and to a limited extent of non-inflammable celluloid and casein, Class G. Parts as shown in Figures 1, 3, 4, and 5 were first made to quite an extent of materials of Class C, but due to the low heat-resisting properties of the shellac materials, these were gradually superseded by the cold molded products of Class B.

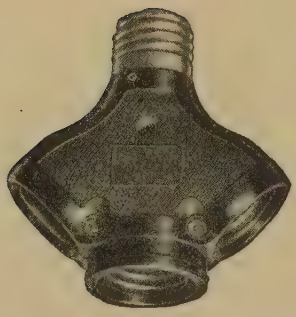

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PLATE III

PLATE III

These molded parts are to-day chiefly produced of cold molded materials, Class B, or porcelain, Class E, with the exception of pig-tail sockets such as illustrated in Figure 3. These can only be produced of the hot molded products of Classes A and C. The high heat necessary for baking the cold molded materials is injurious to the rubber insulated wires soldered on to the brass contact shell, so that it cannot be molded into the piece but must be cemented in later by means of sealing-wax or other cement; while the heat required in hot molding is not sufficient to affect the insulating wires at all. For this reason, the materials of Class C are well suited to make a perfect molded pig-tail or weatherproof socket. Those of Class A are also applicable, but due to the prohibitive cost, they are used to a limited extent.

Plural sockets like in Figure 1 are produced of materials of Classes A and B, the other materials not being suited.

Sockets like in Figure 2 are mostly produced in porcelain, Class E, and only to a limited degree as yet in cold molded materials of Class B. Products of Class A are too high in cost for such purposes and shellac products of Class C do not conform with the rules of the National Board of Fire Underwriters in this instance.

Current tap sockets, Figure 4, are made of porcelain, Class E, and cold molded materials of Class B. The cold molded materials are gradually supplanting porcelain for such parts. This s also the case for parts shown in Figures 5 and 6.

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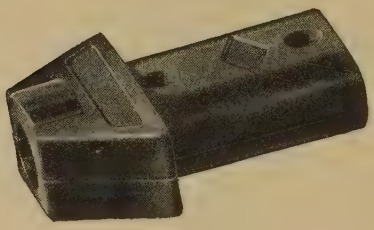

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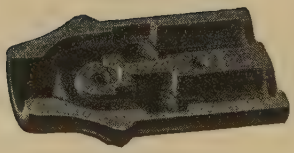

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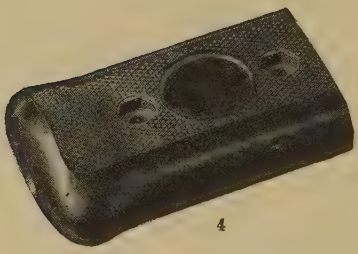

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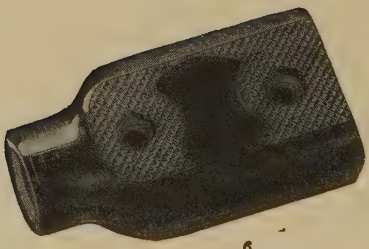

6

PLATE IV

PLATE IV

Molded parts for connectors as shown here are almost exclusively made to-day of cold molded insulation, Class B, which has superseded all other molded materials for such purposes. Inasmuch as the heat requirements necessitate that they stand up without deterioration to a temperature of 500° F., materials of Classes C, F, and G are excluded. The phenol-formaldehyde products of Class A can meet the heat requirements, but due to considerably higher cost, their use for such purposes is limited. The inorganic cold molded materials of Class D are sometimes used for producing these parts, but the high cost of mold upkeep does not permit fair competition with the cold molded materials of Class B.

PLATE V

PLATE V

Molded radiator caps and gear shift lever balls, as illustrated, with male and female inserts molded therein are to-day mostly produced either of the cold molded organic materials of Class B or hot molded phenol-formaldehyde materials of Class A, although years ago such parts were made from hard rubber compositions. A limited number of the gear shift lever balls are also being produced of the shellac materials, Class C.

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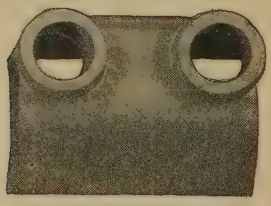

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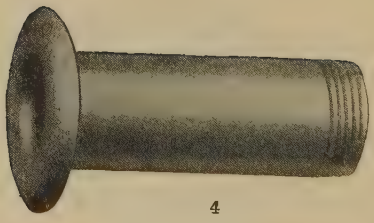

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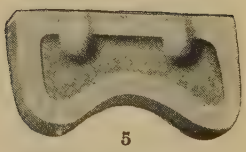

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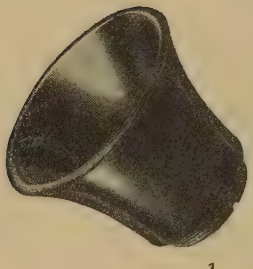
PLATE VI

PLATE VI

These molded parts can be produced only of the high heat-resisting materials of Classes D and E to be suitable for the purposes for which they are intended. The standard type of porcelain, Class E, such as used for electrical wiring devices is not applicable.

Resistance bases like in Figure 1 can be satisfactorily produced only of special high grade heat-resisting materials. Although coils like in Figure 2 can be produced of high heat-resisting porcelain, the author recommends the use of ''Lava Composition'' or ''Molded Lava'' for same. Arc separators, as shown in Figure 5, or any other type of arc separators used in electrical controlling devices are best produced from the cold molded inorganic materials of Class D. No other materials of any of the other classes are suitable. Flat iron terminal separators as in Figure 3 are also more suitable of materials of Class D. Products of Classes A and B would not stand sufficient high heat and the ceramic materials of Class E could not be molded accurately enough and would be too breakable to be used for such purposes.



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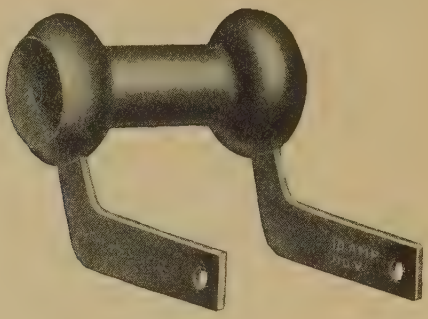

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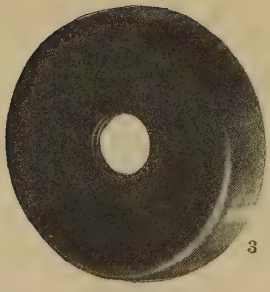

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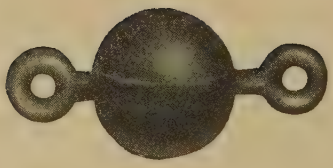

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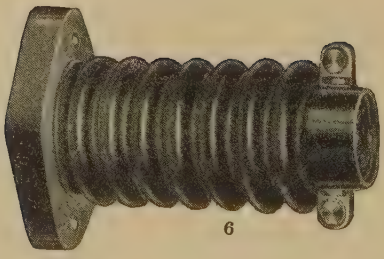

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PLATE VII

PLATE VII

The parts such as shown here are most satisfactorily produced of hot molded materials of either Class A or Class C. Cold molded materials of Classes B and D are not applicable. Hard rubber compositions of Class F were formerly used to a great extent, but in recent years, when quality and resistance to heat are the prime factors, phenol-formaldehyde products of Class A are specified; or when low cost is the main object, the shellac materials of Class C are used to produce such parts.

High tension insulators as in Figure 5, while chiefly produced out of special grades of porcelain, are to-day made to quite an extent of specially compounded shellac materials of Class C.

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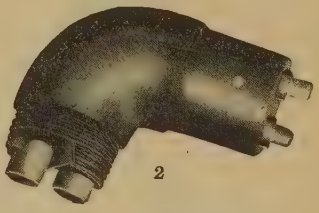

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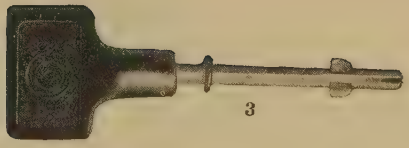

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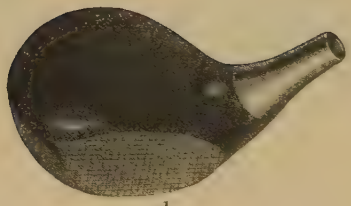
PLATE VIII

PLATE VIII

Such molded parts as shown are produced of hot molded shellac products, Class C, with the exception perhaps of such handles as represented in Figure 1 for which purposes hard rubber composition, Class F, or phenol-formaldehyde products, Class A, are preferably used if high cost is not a factor. Appearance and low cost are the principal items in molded parts of this kind, and for this reason materials of Class C have not been substituted by either the cold molded materials of Class B or the phenol-formaldehyde products of Class A.



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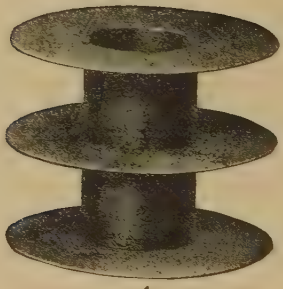

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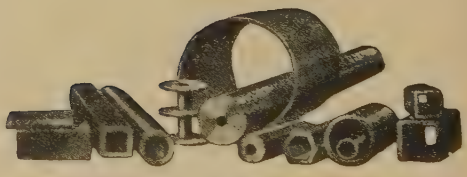
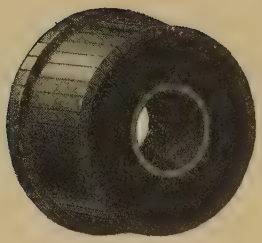


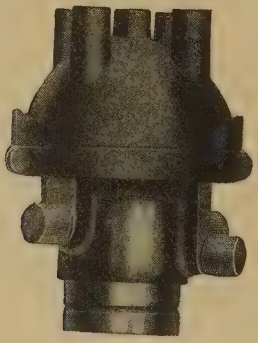
6

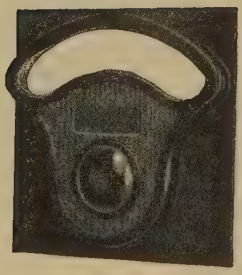
PLATE IX

PLATE IX

These parts illustrate molded materials of the phenol-formaldehyde type, which products alone are suitable for such uses. Gears such as Figure 5 are to-day satisfactorily produced of a laminated material of Class H made with a phenol-formaldehyde binder. Rods and tubes such as in Figure 6, while formerly made almost entirely out of vulcanized fiber, are extensively produced to-day also of the laminated material of Class H. Parts such as illustrated in Figures 1, 2, 3, and 4 being to-day exclusively made of the phenol-formaldehyde materials, Class A, indicate the wide field of adaptability for same.







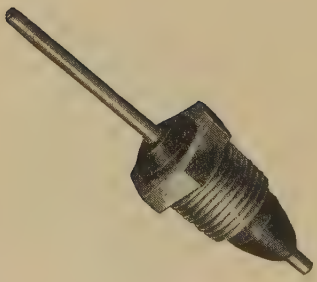
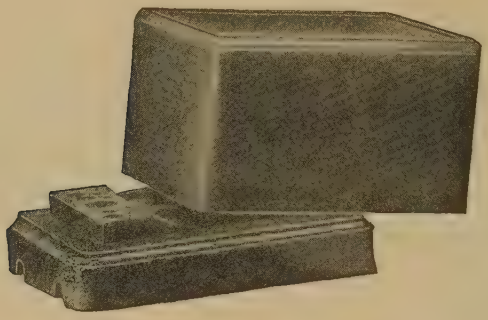
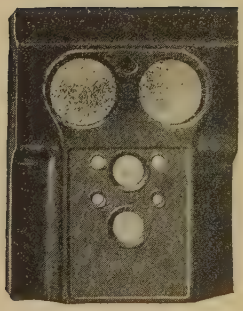


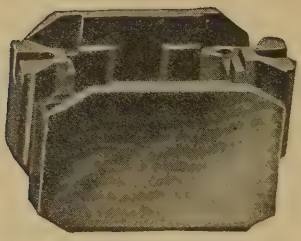
PLATE X

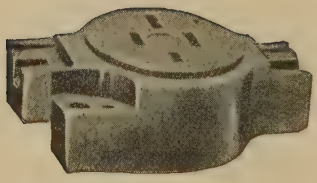
PLATE X

Molded parts such as shown here are satisfactorily producible only of phenol-formaldehyde materials of Class A as accuracy, resistance to high heat, appearance, dielectric properties and mechanical strength are governing factors in the specification of same.





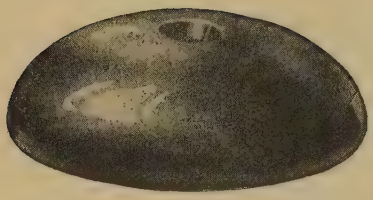




TE XI

PLATE XI

The parts here represented are to-day most extensively produced of materials of Class B, having practically entirely supplanted porcelain. Shellac materials of Class C cannot be used as they are not in accordance with the rules of the National Board of Fire Underwriters owing to their low melting characteristics. The phenol-formaldehyde products of Class A could be used for these purposes but their high cost makes same prohibitive.



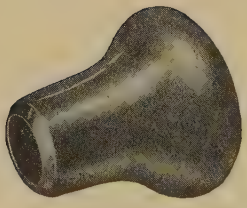


PLATE XII

PLATE XII

The various handles and knobs as shown are most widely produced to-day of cold molded materials of Class B, although if high cost is not a potent factor, the phenol-formaldehyde products of Class A are well adaptable, also the rubber compounds of Class F. Then, too, when the resistance to heat is not a consideration, shellac materials of Class C may be used.

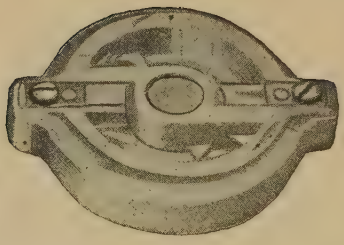


PLATE XIII

PLATE XIII

Parts of familiar design are here shown, which may be molded from materials of Classes A, B, C, D, and E, though for practical reasons the ceramic products of Class E are almost exclusively used at the present time in the production of these and similar parts. This is partly due to the excellent dielectric and physical characteristics of porcelain, but principally to its low cost. As a result, the combined production of such parts from materials of the other classes is far below that of Class E, the ceramic products.

Twenty years ago, porcelain alone was available for such parts, but since that time other classes of molded materials, such as those of Class B have grown in favor, so that at the present time the designer of electrical appliances is no longer limited to porcelain but has at his disposal also the cold molded organic materials of Class B, which gives him a wider range as to appearance and physical qualities, where very low cost is not an absolute essential.

CHAPTER VI

PROPERTIES AND RELATIVE CHARACTERISTICS

In the previous discussion of the materials, of the various classes of molded products, only occasional mention of their properties was made, for the purpose of presenting a brief survey only, to indicate what the different molded materials were, their history, and under what methods they were produced.

However, as each class represents a large number of commercially molded materials known under their individual trade names, and as manufacturers of each of these products may claim superior advantages over the molded articles of their competitors, although their molded products may be subject to the same classification, the author will not attempt to present a detailed description of the properties and merits of molded insulation.

Manufacturers of molded products give considerable data on the properties of their articles, and standard methods of testing have been proposed for dielectric, tensile, compressive, and transverse strength, under various atmospheric conditions, in order to enable the user to subject the material to tests for his particular requirements.

It will be found that hardly two molded materials of the same classification made by different manufacturers will exhibit the same properties and characteristics, and this is due to the skill and experience under which each product of the same class is made. This factor of manufacturing skill and experience is governing as to the superior or inferior properties relative to the various products of the same class.

Therefore, the author here presents only briefly such vitally important properties applying to the various products known under their various trade names, as to the relative basic characteristics of their classification.[1]

LABORATORY TESTS

In describing the various classes of molded insulating materials and reference to their properties in the preceding chart, relative values have been considered only in the abstract, while in the description covering the selection of materials and illustrating typical molded parts, the author made a definite attempt to distinguish between the classes and to establish their individual merits for specific purposes on the basis of practical results obtained and present day usages in the electrical industries.

[1] See pages 270 and 271 for table.

As far as possible, reference to definite laboratory test has been avoided, as liable to be misleading, principally due to variations in raw materials, methods and skill of manufacture, but also due to standardized methods of testing insulating materials not having found practical adoption as yet by the users in general. In 1916, the Standards Committee of the Molded or Formed Insulation Section of the Associated Manufacturers of Electrical Supplies, of which the author was a member, proposed a series of standard testing methods which were then worked out together with the testing methods proposed by the American Society of Testing Materials, as now approved by them and given herewith:

STANDARD METHODS OF TESTING MOLDED INSULATING MATERIALS

SERIAL DESIGNATION: D 48-22

These methods are issued under the fixed designation D 48; the final number indicates the year of original adoption as standard, or in the case of revision, the year of last revision.

PROPOSED AS TENTATIVE, 1917; ADOPTED IN AMENDED FORM, 1922.

Material Covered.

1. These tests are intended to apply to all solid insulating materials that are formed in molds by the application of pressure, either with or without heat.

I. TENSILE STRENGTH

Apparatus.

2. Any standard testing machine may be used. Special clips (see Fig. 1) of hardened steel shall be used, hung from links held in the jaws of the machine, so that the pull is central at all times, to avoid any transverse strain.

Specimen.

3. The standard test specimen shown in Fig. 1 shall be used for the tension test. It shall be molded in a hardened and ground steel mold to the dimensions given in Fig. 1.

Method.

4. (*a*) Five specimens shall be tested in the condition in which they are received.

Three specimens shall be tested after heating in an oven for one hour at a temperature which is 10° C. (18° F.) below the distortion point of the material, as determined in accordance with Sections 18 to 21. Each specimen shall be taken from the oven and tested immediately while hot.

Two specimens shall be tested after they have been entirely immersed in water for 48 hours at normal room temperature. The specimens shall be pulled apart at normal room temperature of about 20° C. (68° F.) after the surface water has been removed by wiping with a dry cloth.

Class	A	B	C	D
Class Designation	Phenol-Formaldehyde	Organic Cold-molded	Organic Hot-molded	Inorganic Cold-molded
Binder	Phenol-formaldehyde-resin	Resins Asphalts Coal tar pitch Stearine pitch Phenol-Formaldehyde	Shellac Dammar rosin pitches Asphalts Cheap resins	Portland cement Oxychloride cements Compounds of silica, alumina, lime and magnesia
Filler	Wood pulp, Asbestos	Asbestos Silica Magnesia	Cellulose (Wood pulp) Cotton, Lime Magnesia Mica Silica Asbestos	Asbestos
Color	Red, Brown, Black	Black	Usually Black	White, Gray Black
Finish	Excellent	Good	Excellent	Poor
Dielectric Strength Volts per mil	200 to 600	80 to 200	100 to 400	40 to 150
Tensile Strength per sq. in.	3000 to 6000	600–3000	900–2000	2500
Compressive Strength per sq. in.	24000 to 35000	500–2500		2000
Moisture Resistivity	Absorbs only slight amt. of water	Absorbs only slight amt. of water if properly compounded	Absorbs only slight amt. of water	Absorbs water freely unless impregnated
Specific gravity	1.3 to 2.	2.	1.1 to 2.7	2.
Effect of age	No effect	No effect	Deteriorates if improperly compounded	Improves with age
Heat Resisting Qualities	150°–250° C.	200°–300° C.	80° C.	550° C.
Oils — Mineral	Unaffected	No effect	Decomposes	No effect
Oils — Organic	Unaffected	No effect	Decomposes	No effect
Alkalis	Slightly affected	Slightly affected	Decomposes	Affected
Acids — Weak	Unaffected	Slightly affected	Decomposes	Decomposes
Acids — Strong	Decomposes	Affected	Decomposes	Decomposes
Metallic Inserts	Can be molded	Can be molded	Can be molded	Can be molded
Machining Qualities	Fair	Fair	Poor	Fair

E	F	G		H
Ceramics	Rubber Compounds	Celluloid	Albuminoids Casein	Laminated Insulation (Phenol-Formaldehyde)
Clay Quartz Feldspar Gypsum Chalk Slate Sodium silicate	Rubber Sulphur	Camphor	Casein	Phenol-formaldehyde resins
		Cellulose		Paper Cloth
White	Gray Black, Red	Usually White	All colors	Red, Gray Black
Good	Excellent	Excellent	Excellent	Good
1000	2000	250–700	125	200–1000
650–2300	1200–2000			18000
6000–30000	2000–4500			30000
Waterproof if glazed	Waterproof	Waterproof	Softens or warps slightly under continuous exposure to water	Absorbs only slight amt. of water
2.5	1.12–1.40	1.44	1.35	1.3 to 1.4
No effect	Very little effect if properly compounded	No effect	Very little effect	No effect
600°–1000° C.	90° C.	75° C.	85° C.	150° C.
No effect	Softens	Decomposes	Decomposes	Unaffected
No effect	Unaffected	Decomposes	Decomposes	Unaffected
No effect	Unaffected	Decomposes	Decomposes	Affected
No effect	Unaffected	Decomposes	Decomposes	Unaffected
No effect	Unaffected	Decomposes	Decomposes	Decomposes
Cannot be molded in	Inserts Corrode			Unsatisfactory for molding
Impossible	Excellent	Excellent	Excellent	Excellent

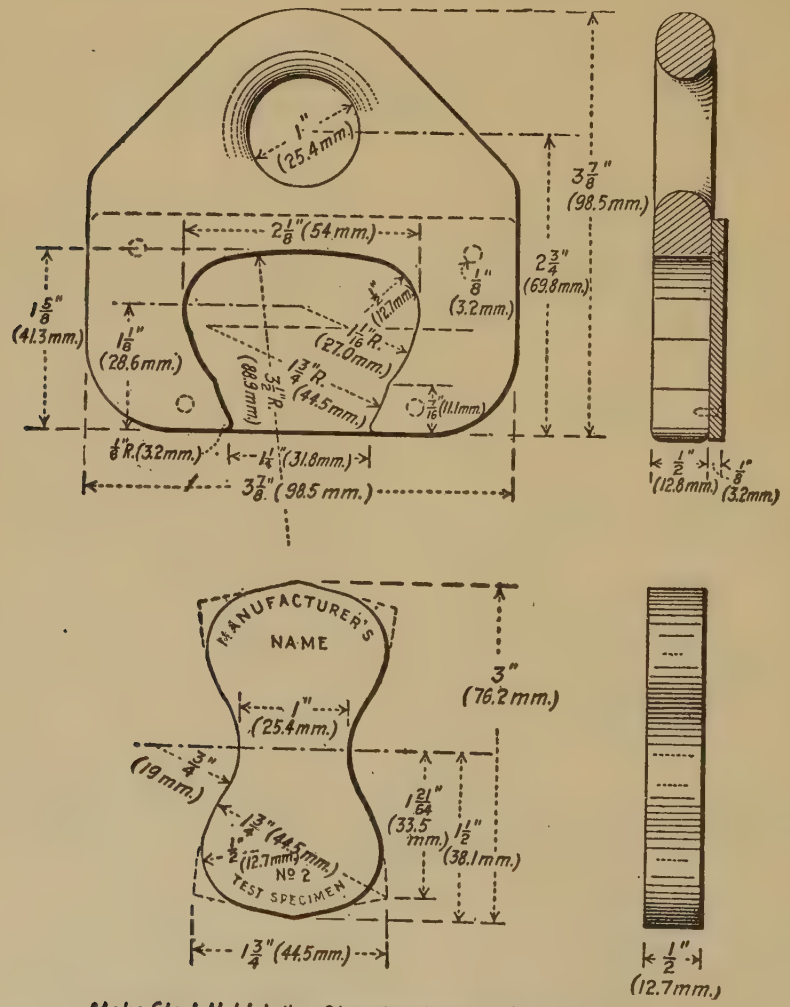
(*b*) The test specimen shall be pulled apart at such a speed that the beam can be kept well balanced. All tests shall be made at normal room temperature of about 20° C. (68° F.). Measurements may be taken at intervals during the test to show the elongation of the specimen when required for elastic materials.

Report.

5. The report of test shall include:

(*a*) The breaking load of each specimen in pounds or kilograms;

(*b*) The thickness of each specimen in inches or centimeters as



Make Steel Mold to these Dimensions. Limits ± 0.002 (0.05mm.)

FIG. 1.—Tension Test Specimen (Specimen No. 2).

measured by a micrometer at the center of the specimen, that is, the point of minimum section.

(*c*) The ultimate tensile strength in pounds per square inch or in kilograms per square centimeter of each specimen, calculated from the minimum area measured at the center of the test specimen before the load is applied.

(*d*) The character of the material tested, with description of how it acts under stress.

(*e*) The speed in inches or centimeters per minute at which the jaws traveled during the test.

II. Compressive Strength

Apparatus.

6. Any standard testing machine may be used. The pressure head used for standard compressive strength tests of cement blocks is satisfactory for this purpose. A sheet of soft annealed copper about $\frac{1}{32}$ in. (1 mm.) thick, or heavy blotting paper, shall be placed above and below the specimen to equalize irregularities.

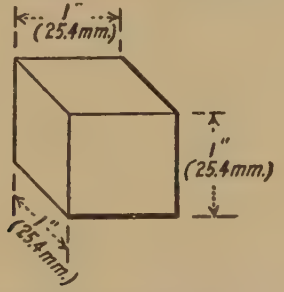


Fig. 2.—Compression Test Specimen (Specimen No. 3).

Specimen.

7. The test specimen shall be molded in the form of a cube from a hardened steel mold, ground to the dimensions shown in Fig. 2.

Method.

8. (*a*) Five specimens shall be crushed in the condition in which they are received.

Three specimens shall be crushed after heating for one hour at a temperature which is 10° C. (18° F.) below the distortion point of the material as determined in accordance with Sections 18 to 21. Each specimen shall be taken from the oven and tested immediately while hot.

Two specimens shall be crushed after immersion in water at normal room temperature for 48 hours, with all surface water wiped off with a dry cloth.

(*b*) The load shall be applied in a direction at right angles to that in which the pressure was applied in molding, and at such a rate of speed that will permit the beam to be kept well balanced from zero load until the specimen is crushed. For the best results use the slowest possible speed.

Report.

9. The report of test shall include:

(*a*) The dimensions of each specimen in inches or in millimeters;

(*b*) The load in pounds or kilograms, on each specimen at the first sign of failure;

(*c*) The ultimate compressive strength in pounds per square inch or kilograms per square centimeter, of each specimen, calculated from the measured area of each specimen before the load is applied;

(*d*) The general character of the material tested, with description of how it acts under the applied load;

(*e*) The speed in inches or centimeters per minute at which the jaws traveled during the test.

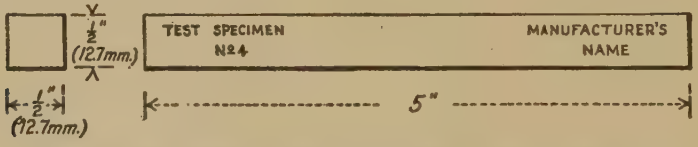


FIG. 3.—Transverse Test Specimen No. 4.

III. TRANSVERSE STRENGTH

Apparatus.

10. Any standard testing machine may be used. The specimen shall be supported on two steel blocks, with corners rounded to $\frac{1}{16}$-in. (1.5-mm.) radius. These supports shall be not more than 4 in. (102 mm.) nor less than 2 in. (51 mm.) apart. The load shall be applied on top of the specimen in a direction at right angles to the direction in which the piece was molded, by means of a wedge-shaped pressure piece, the edge of which is rounded to a $\frac{1}{8}$-in. (3-mm.) radius, extending across the specimen with the edge parallel to the edges of the two supports. The angle of the wedge shall be approximately 45 deg. and the load shall be applied at right angles to the specimen midway between the supports. The specimen shall be laid flat upon the supports at equal distances from the edge at each end.

Specimen.

11. The test specimen shall be molded from a hardened steel mold, ground to the dimensions shown in Fig. 3.

Method.

12. (*a*) Four specimens shall be tested in the condition in which they are received.

Three specimens shall be tested after immersion in water at normal room temperature for 48 hours with all surface water wiped off with a dry cloth.

(*b*) The load shall be applied at as slow a speed as possible, so that the beam may be well balanced from zero load until the first sign of failure. All tests shall be made at room temperature of about 20° C. (68° F.). Measurements of the deflection may be taken for very elastic materials.

Report.

13. The report of tests shall include:

(*a*) The thickness and width of each specimen as measured by a micrometer in inches or millimeters;

(*b*) The load on each specimen in pounds or in kilograms at the first sign of failure;

(*c*) The maximum fiber stress in pounds per square inch or in kilograms per square centimeter calculated from the formula:

$$S = \frac{3\ Pl,}{2\ bd^2}$$

in which S = maximum fiber stress, P = load applied, l = distance between the support, b = width of specimen, and d = depth of specimen;

(*d*) The rate at which the load was applied;

(*e*) The amount of deflection at the center in inches or in millimeters;

(*f*) The distance between the supports in inches or in millimeters.

IV. Dielectric Strength

Apparatus.

14. (*a*) Any well-designed high tension transformer connected to an alternating current supply having as nearly a true sine wave as possible, may be used. The transformer and the source of supply of energy shall be not less than 2 kva. for voltages of 50,000 volts or less, and not less than 5 kva. for voltages above 50,000 volts. The frequency shall not exceed 100 cycles per second.

(*b*) Regulation shall be so controlled that the high tension testing voltage taken from the secondary of the testing transformer can be raised gradually from any point and in no case more than 500 volts at a step. The control may be made by generator field regulation, with an induction regulator, or with a variable ratio auto transformer. Any method of regulating the voltage is satisfactory which does not distort the wave more than 10 per cent from a sinusoidal shape.

(*c*) The voltage may be measured by any approved method which gives root-mean-square values, perferably by means of a voltmeter connected to a special voltmeter coil in the high tension winding of the testing transformer or to a separate step-down instrument potential

transformer. A voltmeter on the low tension side of the transformer is satisfactory, if the ratio of transformation does not change under any test condition. An electrostatic voltmeter properly calibrated in the high tension circuit is also satisfactory. A spark gap may be used to check the readings at very high potentials.

(*d*) Some protection is desirable in the high tension circuit of testing transformers where the potential is 25,000 volts or over, to prevent dangerous surges and limit the current when the test specimen is punctured. It is, however, desirable to have as much energy available as possible when puncture occurs. If impedance in the form of choke coils be used in series with the high tension terminals, it should not be greater than that which will limit the high tension current to double the normal rated current of the testing transformer.

When a spark gap is used, a non-inductive resistance of about one ohm per volt may be inserted in series with one terminal of the spark gap, to damp high frequency oscillations at the time of breakdown and limit the current flow. This resistance shall be as near the gap as possible. If the test is made with one side grounded, this resistance shall be on the ungrounded side of the circuit, and if neither side is grounded the resistance shall be inserted one-half on each side of the spark gap. Water tube resistors are preferable to carbon for this purpose, as carbon resistance may be materially decreased by the passage of current.

(*e*) The apparatus used and the method of measuring the voltage shall meet the requirements of the standardization rules of the American Institute of Electrical Engineers.

Specimen.

15. The test specimen shall be molded to the dimensions shown in Fig. 4. The mold shall be hardened and ground to these dimensions. If the material cannot be molded to the full height shown, the height may be reduced to 1¼ in. (31.7 mm.).

For materials having a puncture value higher than 300 volts per mil, the thickness of the bottom of the specimen may be reduced to 0.098 in. (2.5 mm.). It should be noted, however, that the apparent dielectric strength in volts per mil may be increased as much as 50 per cent when the thickness of the bottom of the specimen is so reduced.

Method.

16. (*a*) Voltage shall be applied to the test specimen by floating the specimen on mercury and placing a pool of mercury about ⅛ in. (3 mm.) deep inside the specimen.

It is recommended that all tests be made in air, but whenever it is impossible to puncture the specimen in air without arcing over the edge, it shall be immersed in high grade transformer oil. On specimens which require a very high voltage to puncture, it may be necessary to put a glass tube or shield over the wire leading to the mercury on the inside of the specimen in order to prevent breakdown over the surface of the oil between terminals. The testing voltage shall be raised at a constant rate of approximately one thousand volts per second until puncture occurs.

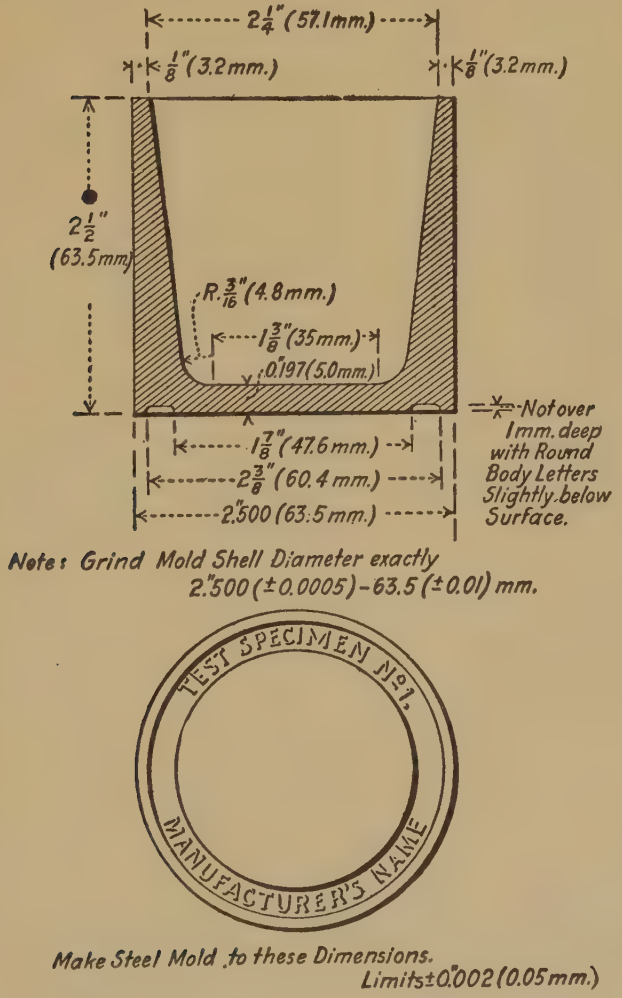

2 1/4" (57.1mm.)
1/8" (3.2mm.)
1/8" (3.2mm.)
2 1/2" (63.5mm.)
R. 3/16" (4.8mm.)
1 3/8" (35mm.)
0.197 (5.0mm.)
Not over 1mm. deep with Round Body Letters Slightly below Surface.
1 7/8" (47.6mm.)
2 3/8" (60.4 mm.)
2.500 (63.5mm.)
Note: Grind Mold Shell Diameter exactly 2.500 (±0.0005) - 63.5 (±0.01) mm.
TEST SPECIMEN No. 1.
MANUFACTURER'S NAME
Make Steel Mold to these Dimensions. Limits ±0.002 (0.05mm.)

FIG. 4.—Test Specimen No. 1 for Dielectric Strength.

(*b*) Five specimens shall be punctured in the condition received at normal room temperature of about 20° C. (68° F.) in order to determine the uniformity of the molded material.

Three specimens shall be punctured after heating one hour in an oven heated to 10° C. (18° F.) below the distortion point of the material as determined in Sections 18 to 21. The specimen shall be taken from the oven and immediately punctured in air while hot. This test is intended to cover all molded materials which do not withstand working temperatures above 125° C. (257° F.). Tests on ma-

terials which resist high temperatures may be made above 125° C. (257° F.) when required.

Two specimens shall be punctured after they have had the rim immersed in melted paraffin for a depth of 1 in. (25.4 mm.) and have been entirely immersed in water for 48 hours at normal room temperature of about 20° C. (68° F.). The surface of the specimen shall be wiped off with a dry cloth to remove all trace of excessive surface moisture and the puncture test immediately made.

(*c*) The results from specimens where puncture takes place up on the side of the specimen instead of through the bottom shall be discarded. Experience shows that very plastic materials which flow easily in the mold always puncture through the bottom, while materials which do not mold readily will often puncture through the side walls of the specimen at some distance up from the bottom.

Report.

17. The report of test shall include:

(*a*) The thickness of the bottom of each specimen measured with a micrometer in the direction perpendicular to the bottom surface, and also the thickness at the point of puncture, regardless of the path taken by the discharge. The thickness of each specimen shall be given in mils or in millimeters;

(*b*) The puncture voltage of each test specimen expressed in terms of the effective (root-mean-square) value;

(*c*) The volts per mil or per millimeter as calculated from the measured thickness of the bottom of the specimen;

(*d*) The general character of the material tested with regard to leakage, if any is observed.

V. Distortion under Heat

Apparatus.

18. A special apparatus shall be used for this test as shown in Fig. 5. The specimen is supported on steel supports, 4 in. (102 mm.) apart with the load applied on top of the specimen vertically and midway between the supports, the same as for the transverse test, Section 10. The machine shall be arranged to apply to a load of 5½ lb. (2.5 kg.). The specimen shall be placed in an air bath surrounded by an oil bath which is so arranged that its temperature may be raised gradually. The machine shall be so arranged that the deflection of the specimen at its center between the supports can be measured on a scale in mils or millimeters and shall be equipped with a thermometer so that the temperature of the specimen can be recorded at any time. The machine may be arranged to automatically shut off the heat and sound an alarm as soon as the required deflection is reached.

Specimen.

19. The same test specimen shall be used for this test as required for the transverse strength test, Section 11, molded from a hard steel mold ground to the dimensions given in Fig 3.

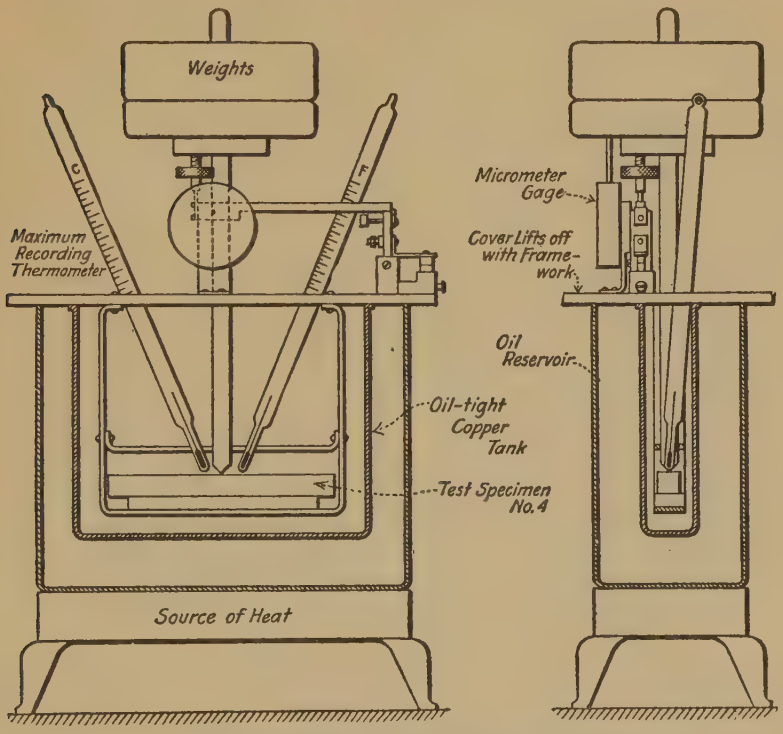


FIG. 5.—Machine for Temperature Tests.

Method.

20. Three test specimens shall be tested in the condition in which they are received, starting at normal room temperature of about 20° C. (68° F.) and increasing the temperature gradually at the rate of approximately 1° C. every two minutes.

The distortion point shall be considered the temperature at which the specimen has deflected 10 mils (0.254 mm.) at the center between the supports.

Report.

21. The report of test shall include:

(*a*) The breadth and depth of each specimen measured at the center with a micrometer in inches or in millimeters;

(*b*) The distortion point in degrees Centigrade or in degrees Fahrenheit;

(*c*) The length of time in minutes required for each specimen to deflect 10 mils (0.254 mm.);

(*d*) Any peculiar characteristics of the material as noted either during the test or after the specimen is removed from the machine;

(*e*) A curve for each test specimen showing the time in minutes

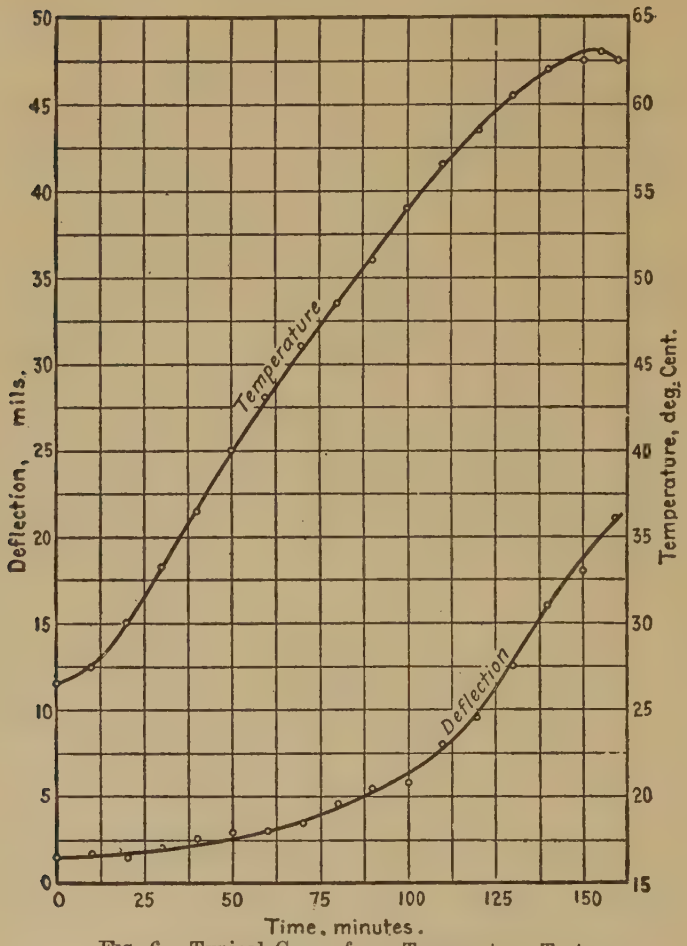


FIG. 6.—Typical Curve from Temperature Test.

horizontally and the amount of deflection and also the temperature at given intervals, as vertical ordinates as shown in Fig. 6.

VI. EFFECT OF MOISTURE

Apparatus.

22. Any good chemical balance, a beaker of water at normal room temperature of about 20° C. (68° F.), and an oven of any standard make capable of maintaining a uniform temperature of 100° C. (212° F.) with a variation allowed of ± 5° C.

Specimen.

23. The test specimen No. 1 shown in Fig. 4 shall be used for this test. After the puncture tests prescribed in Section 16 (*b*), are completed on the five specimens, three of them shall be taken and the

entire rim of each specimen shall be sawed off with a hack saw ¼ in. (6 mm.) back from the top edge of the specimen so as to expose a more or less uniformly cut surface.

Method.

24. Weigh each of the three test specimens after the rim has been sawed off. If the material softens readily at moderate temperatures, the specimen may be placed in a desiccator for 24 hours, or in an oven at a temperature of 50° C. (122° F.), permissible variation ± 5° C., for 24 hours. For materials which do not soften readily, the specimen shall be placed in an oven heated to 100° C. (212° F.), permissible variation ± 5° C., for 24 hours. After drying, the pieces shall be cooled in a desiccator and weighed again at normal room temperature. The specimens shall be placed in water, wholly immersed, for 100 hours at normal room temperature. They shall then be removed from the water at the end of 100 hours, all surface water wiped off with a dry cloth, and the specimens weighed immediately.

Report.

25. The report of test shall include:

(*a*) The original weight of each specimen;

(*b*) The dry weight of each specimen;

(*c*) The weight of each specimen after immersion for 100 hours;

(*d*) The percentage of moisture contained in each test specimen as received, and the percentage of moisture absorbed during the 100 hours, taking the dry weight as 100 per cent.

All weights shall be given in grams.

J. H. Dellinger and J. L. Preston of the Bureau of Standards in publication No. 216, Properties of Electrical Insulating Materials of the Laminated Phenol-Methylene Type, July 21, 1922, have presented very thorough comparative data and testing methods on materials of Class F (Hard Rubber) and Class H (Materials of the Laminated Phenol-Methylene Type) as to volume resistivity, surface resistivity, voltage effects at radio frequencies, phase difference and dielectric constant at radio frequencies, tensile strength, proportional limit and modulus of elasticity and rupture, proportional limit and modulus of elasticity, hardness, impact strength, distortion under dead weight, density, moisture absorption, machining qualities, thermal expansivity, heat effects of acid and alkali.

The publication is of particular interest and value in the consideration of insulating materials to be used for radio work.

The author will refer to another excellent scientific paper of the Bureau of Standards, No. 234, by Harvey L. Curtis, issued in 1914, relating to tests made on Insulating Properties of Solid Dielectric such as: Amber, Amberite (Class C), Bakelite (Class A), Bakelite-micarta (Class H), Beeswax, Celluloid (Class G), Ceresin, China oil, Condensite (Class A), Dielectrite (Class F), Duranoid (Class C), Electrose (Class C), Galalith (Class G), Glass (Class E), Glytol (Class A), Gumon (Class B), Halowax, Hard Rubber (Class F), Hemit (Class D),

Insulate No. 2 (Class C), Ivory, Khotinsky cement, Lavite (Class E), Linseed oil, Marble, Mica, Molded mica (Class H), Murdock No. 100 (Class C), Paraffin, Porcelain (Class E), Quartz, Redmonite No. 157-4 (Class A), Rosin, Sealing wax, Shellac, Slate, Stabilite (Class F), Sulphur, Tegit (Class B), Tetrachlornaphthalene, Wood.

Another tentative method of test for phase difference (Power factor) and dielectric content of molded electrical insulating materials at radio frequencies is proposed by the American Society for Testing Materials, their serial Designation D 150 — 22 T.

Although the author is informed that some additional publications by the Bureau of Standards on tests and properties of insulating materials of the molded type will follow, in the meanwhile he will present the results of some tests made for him by the Electrical Testing Laboratories of New York, under the personal supervision of Mr. P. M. Farmer, such tests approaching, as nearly as possible, practical conditions as met in his own experience.

In order to render such tests as nearly as possible comparative, commercial samples of the more generally manufactured insulating products have been procured rather than special samples prepared with a knowledge of the purpose for which they were required.

The results given do not, therefore, cover all of the products of the classes of materials tested, as these would show wide differences due to variations in methods of preparation, quality of binders and fillers used, and conditions of manufacture. It follows in some instances that, as has already been stated, the reverse of conclusions based on such tests would hold where products, seemingly inferior under the laboratory test, would prove superior for practical purposes of service.

In the tests which follow, reference has, in some cases, been made to two or three products of the same class indicated by the letters a, b, etc. This has been done to demonstrate the wide range of results that may be obtained from different commercial products manufactured on the same general principle and in the same class of material.

Materials of Classes E, F, G and H being more generally known and understood, it has not been thought necessary to give them a place in these tests which are confined to the more recently introduced materials of Classes A, B, C and D.

Dielectric Strength Tests

These tests were made with samples of the following shapes and obtained as follows:

Class A. Plates 2½″ x 1⅞″ x ½″ cut from molded plates 6″ x 4″ x ½″.

Class A. (a). Molded bushing, irregular shape, 3″ x 2⅜″ over all.

Class B. Cover, over all dimension 2⅜″ x 2⅜″ x 1⅜″ high, width, ½″ wall.

Class B. (a). Caps for hexagonal nuts or bolts, maximum width of head, 1″, thickness of wall, ½″.

Class C. Plates $3\frac{1}{4}'' \times 2\frac{1}{2}'' \times \frac{5}{16}''$ thick, cut from one plate $5'' \times 7'' \times \frac{5}{16}''$.

Class C. (a). Plates $3'' \times 3'' \times \frac{3}{8}''$ cut from one plate $7'' \times 7'' \times \frac{3}{8}''$.

Class G. Plates $4'' \times 2\frac{5}{8}'' \times \frac{3}{8}''$ cut from one plate $8'' \times 6'' \times \frac{1}{2}''$.

Class G. (a). Plates $4'' \times 2\frac{5}{8}'' \times \frac{1}{2}''$ cut from one sheet $8'' \times 8'' \times \frac{1}{2}''$.

Class G. (b). Molded bushing $1\frac{5}{8}'' \times 1\frac{3}{4}''$ over all.

The dielectric strength tests were made with the sample placed between blunt needle points; voltage was applied to the needle points at a low value, and gradually increased until puncture occurred. The high tension voltage was measured by means of a voltmeter connected across the low tension winding of the transformer, the ratio being known. The current was obtained from a 60 cycle course, the wave form of which is practically a sine curve.

Insulation Resistance Tests

The samples submitted for this test were the same as those used for the puncturing tests. They were first used for measurements of the resistance, and afterwards for the puncture tests.

The insulation resistance was measured by the usual high sensibility series galvanometer method, the time of electrification being one minute. Voltage of 150 and 700 volts were employed, depending upon the value of insulation resistance to be measured. The electrodes employed were containers. A guard ring was employed so that the question of surface leakage was thereby eliminated.

When the immersed samples were withdrawn from the water, the excess surface moisture was removed with blotting paper. Since the samples were very small and the guard ring near the edge, it is probable that the leakage current was relatively large and the result must be considered of questionable value.

Tensile Strength Tests

Samples for these tests were submitted in the form of standard briquettes used in cement testing. These briquettes were cut out of blocks about 1″ thick of the respective materials.

These tests were made in a standard tensile testing machine having a capacity of 4,000 lbs. The jaws employed corresponded in design with the standard shape used in testing cement briquettes.

Arc Tests

The following samples were submitted for tests:

Class B. Molded piece of irregular shape $1\frac{5}{8}'' \times 2\frac{3}{8}'' \times \frac{1}{4}''$ over all.

Class D. Molded block $4\frac{1}{2}'' \times 2\frac{5}{8}'' \times 2\frac{1}{2}''$.—Silica Lime.

Class D (a). Molded block $5'' \times 3'' \times \frac{3}{4}''$.—Portland Cement.

Class D (b). Disc $4\frac{1}{2}'' \times \frac{3}{8}''$.—Impregnated.

Class A. Block $3'' \times 1'' \times 1''$.

Class A (a). Block $2\frac{3}{4}'' \times 1\frac{3}{4}'' \times \frac{5}{8}''$.

CLASS	DIELECTRIC TEST—VOLTS PER MIL.							INSULATION TEST—MEGOHMS PER CU. IN.				TENSILE STRENGTH LBS. PER SQ. INCH	ARC TEST
	AS REC'D	IMMERSION		HEATING				AS REC'D	IMMERSION	HEATING			
		After immersion in water 72 hrs.	After immersion in transformer oil at 75° C. 12 hrs.	After subjecting to temp. of 100° C. for 12 hours	200° C. for 12 hours	300° C. for 12 hours	300° C. for 12 hours cooling, then immersing in water 24 hrs.		in water 72 hrs.	Temp. of 100° C. for 12 hours	Temp. of 200° C. for 12 hours		a. Held ¼" above flame of arc 1 minute. b. Passed slowly through part of flame of arc. c. Held in flame of arc for 1 minute. d. Ignited when possible and then held in the open air. e. Carbonized when possible; held across the extinguished arc, carbon still hot, to re-establish arc. f. Same as "e" except carbons were first allowed to cool.
*A	221. 213. 218.	40. 36. 38.	30.3 29.8 31.	65.7 67. 63.	102.5 109. 101.	....	... ...	65. 93. 76.	51. 40. 42.	1790. 2310. 3840.	850000. 970000. 680000.	3020. 4000. 2920. 3405.	a. Caught fire slowly. b. Caught fire but stopped on leaving arc. c. Caught fire and burned in air a little. d. Caught fire and burned in air a little. e. Charred and became conducting. f. Charred and became conducting.
**Aa	326. 315. 333.	235. 228. 241.	186. 184. 180.	163.5 159.6 166.	119. 116. 124.	....	... ...	....	7590. 11400. 8100.	250000. 340000. 376000.	1000000. 1000000. 1000000. and over	4750. 3780. 2880. 3860.	a. Caught fire instantly. b. Caught fire and continued to burn. c. Caught fire and charred. d. Caught fire and burned for about 1 minute. e. Charred and became conducting.
B	91.8 83.5 88.	53. 58. 55.	193. 169. 188.	90. 84. 91.	98. 101. 96.	96. 105. 102.	80. 78. 83.	21300. 18070. 12300.	470. 380. 710.	25800. 36100. 30400.	350000. 405000. 341000.	1550. 920. 1285. 1421.	a. Became red hot and charred slightly. b. Charred but did not catch fire. c. Became red hot and charred. d. Became red hot, would not burn. e. When carbonized was conducting. f. When carbonized was conducting.
Ba	167. 148.7 159.3	121. 118. 107.	....	....	....	....	... ...	51200. 40700.	14300. 17210.	....	....	....	....

C	152. 178. 143.	114. 110. 103.	152. 170. 164.	87.7 91.1 86.	67. 60. 62.	....	... ...	235710. 60700. 174200.	513. 890. 1070.	1000000. 1000000. 1000000. and over	1000000. 1000000. 1000000. and over	2000. 940. 1090. 1010.	Unsuitable for arc purpose. ....
Ca	361. 350. 353.	287. 293. 301.	....	....	....	....	... ...	1000000. 1000000.	800000. 600000.	....	....	....	..... Unsuitable for arc purpose. .....
D	69.5 72.2 70.8	42. 40. 45.	145. 149. 147.	70. 73. 68.	74. 79. 76.	94. 90. 96.	55. 57. 54.	290000. 115000. 240000.	900. 1320. 1150.	1000000. 1000000. 1000000. and over	1000000. 1000000. 1000000. and over	2230. 1985. 2478. 2918.	a. No noticeable effect. b. Fused quickly to glass-like substance. c. Fused slowly. d. Would not burn. e. Non-combustible and non-conducting. f. Non-combustible and non-conducting.
Da	46.2 41.7 45.	....	....	....	....	....	... ...	24900. 28100.	21110. 19000.	....	....	....	a. No noticeable effect. b. Fused slowly. c. Fused slowly. d. Would not burn. e. Non-combustible and non-conducting. f. Non-combustible and non-conducting.
*** Db	136. 90.	129. 79.	....	....	....	....	... ...	No record taken				....	a. Charred slightly. b. Caught fire slowly. c. Caught fire and fused. d. Would not burn outside of arc. e. Fused portion was conducting. f. Fused portion was non-conducting.

* Asbestos Filler.
** Wood Pulp Filler.
*** Impregnated.

REVIEW OF PATENTS
ON
MOLDED ELECTRICAL INSULATION

In the pages that follow there have been collected together brief abstracts of recent patents on molded materials. The abstracts have been made as concise as possible, yet will be found sufficiently comprehensive to give a reader familiar with the art of plastics an adequate idea of the nature and purpose of the patented invention.

Inasmuch as there is not in existence, so far as known to the writer, any other similar compilation on this subject, it is hoped that this collection of abstracts will prove of value to persons interested either in the technique or in the patent situation of the art.

Many of these patents show that they were taken out by inventors who were not familiar with the chemical or physical properties and reactions of the combined ingredients, nor with the practical uses and purposes for which their inventions were intended. Most of the inventions in the plastic industries are the result of ideas originated by laymen but gradually developed into commercial practicability by the trained chemist and engineer.

Lately, patents have been issued in the United States and Great Britain on molding compounds consisting of resin, rosin, asphalt, and asbestos. Such combinations are really no invention, as they were probably known before the patentees were born. However, let the trained chemist or chemical engineer make up his mind to develop a practical formula and commercial working process on the original basis of this combination, with endurance, and with ability to hold out financially, in most cases he will then succeed and present a compound adapted for use for one purpose or another in the molding art.

With regard to the literature of the United States, British, and French patents for the last ten years or more, on the subject of plastics or molding substances and methods, the author frankly states that probably 90% of the patents issued are either a substantial repetition of old patents and otherwise published literature on the subject; or else the formulæ, descriptions, methods of process, or commercial applications in the plastic arts, are impractical or wholly incapable of realization. Only some of the most interesting and important patents are recorded in this chapter, but there are an enormous number of others, reference to which would be waste of printer's ink to dwell upon, as they are of no value or interest whatsoever.

When we consider the large volume of applications for patent protection on such materials as: plastic compounds, artificial stones, synthetic resins, artificial wood, leather, rubber, celluloid; and on the methods of combining various chemical substances to form plastic com-

pounds and to mold them, the difficulties that confront the Patent Office and Patent Examiners are obvious. In other fields the examiners have at their disposal well defined data, either from actual experience, academic instruction, or reference literature; but when we come to the art of Plastics, particularly in the case of such compounds as are described under Classes A, B, C, and D, of this book, the granting of patents is practically a matter of guesswork; for unless the examiner is personally familiar with molding compounds and molding methods either through laboratory research or manufacturing experience, or has at his command reliable information on what can he base his judgment of the utility of the composition or process claimed?

Up to recent date, the technical schools have not embodied the study of molded materials in their science curriculum; until this is done, the chemist, the engineer, and the patent lawyer will be at sea in regard to passing on the validity, scope and value of patents relating to this subject. The author has had some interesting and amusing experiences in following up patent literature on plastics and testimony, in litigated cases, by highly paid "experts" who were absolutely unfamiliar with the history and vital points of the materials involved. The professional standing of the witness, the patentee, or his attorneys, has in many such cases influenced the courts to render decisions which are in direct contradiction to precedents within the last ten years. In some cases a patentee was upheld in court, primarily because the patentee was the first one to introduce his inventions commercially, and no attention was paid to previous patent literature setting forth essentially the same formula and process. On the other hand, many a patentee has lost his infringement suit against a competitor, owing to some slight defect in the wording of his patent claims, or on citation of previous patent literature, although he was really the first one to introduce his products and molding methods commercially and on a practical basis.

However, as the art of plastic materials is making rapid headway, it may reasonably be hoped that keen competition and the general interest in methods employed will bring order out of chaos in the patent situation. The author predicts that within the next ten years engineers and chemists will receive, as part of their technical schooling, the fundamental and theoretical knowledge of plastics which they will successfully apply and then extend by their own efforts, in practical application. The plastic expert will be specially trained, and will have the same advantages as the chemist, the engineer, the lawyer, and the doctor each enjoys to-day in his particular line.

PATENT REFERENCES

B. P. 16,737/08 Diesser. Substances intended to be used as varnishes or as materials for impregnation and insulation, are made by causing reactions to take place between fatty acids or their compounds (as oils) or substances containing fatty acids or their compounds, and amino acids (such as glycerol) or their compounds, or substances containing amino acids or their compounds (in particular albuminous and albuminoid substances).

F. P. 393,219/08 Stand Varnish Works. A solid insulating material is composed of kauri gum 45.359 kg., colophony 11.325 kg. and castor oil 22 liters.

F. P. 396,340/08 Winkler. Making a transparent, flexible and infusible insulating material by heating cod liver oil 50, pinaline 45 and manganese resinate 5 parts, up to 275 deg. The product is applied at a temperature of 150 deg. and the covered article is heated in an oven to 450 deg.

U. S. P. 939,450/09 Ferla. Electrical insulator. Fire-, acid- and water-proof composition. Asbestos, hemp and hydraulic cement are mixed dry and then combined with acetic acid, glue and water, formed into layers on a screen and pressed into composition board.

U. S. P. 939,982/09 Baekeland. A substitute for hard rubber in insulators, etc., is made of asbestos 30, tar or pitch 30, cotton 4 and carnauba wax 0.5 part.

U. S. P. 940,188/09 Peterson. As an insulating fabric, paper is coated with shellac, then with fragments of mica over which another layer of paper is applied which is also shellaced.

B. P. 2,127/09 Peterson. Production of an insulator by steam-treating a mixture formed of silica and an alkaline earth hydroxide, the latter being in such excess that the product of the treatment contains free hydroxide.

B. P. 23,225/09 General Elec. Making insulating material by mixing kaolin, lime, glass, green silko and red silko, reducing them to a powder, silicate, adding asbestos, forming the mixture into sheets which are treated with sodium, subjecting to pressure and firing at a high temperature.

G. P. 229,301/09 Westinghouse. Making an insulating material for electric apparatus from aluminum foil by passing it through a bath of ammonium borate while passing a current. A film is obtained consisting of aluminum oxide.

G. P. 232,449/09 Kesler. A glue solution to which glycerol has been added, and asbestos, are added to a mixture of cement and pyrolusite. The product is said to be especially suitable for separators in electrical apparatus.

G. P. 242,059/09 Cramer. In making an elastic insulating material, especially for high tension conductors, asphalt is freed, by heating with exclusion of air, from volatile, malodorous (especially sulphur containing) compounds, intimately mixed with petroleum at a temperature above its melting point, with the addition of a solution of aluminum acetate, and also alkali and resin. To 100 parts of this mass, in a fused state, is added vegetable oil (linseed) 30–40 parts, which has been completely dehydrated, purified and oxidized, the product is mixed with sulphur and vulcanized and worked thoroughly after cooling.

U. S. P. 945,800/10 Powers. A composition for waterproofing, or insulating receptacles for liquids, is formed of clay and linseed, cottonseed or rosin oil 3–20%, vulcanized by sulphur in the clay. "Long Island blue clay," described in Technology Quarterly, 18, 1900, is used with or without preliminary removal of iron by nitric acid.

U. S. P. 952,150/10 Smith. A compound for insulation, etc., consisting of rubber 20, shoddy (reclaimed rubber) 30, sulphur 2, litharge 5, and pulverized grahamite 57 parts.

U. S. P. 956,870/10 Wright. A refractory waterproof insulating composition

is formed of soapstone 64, clay 34 and cryolite 4 parts, ground, moistened, mixed, compressed and fired at 900–1100 deg. (preferably 950 deg.) to slightly fuse the cryolite.

U. S. P. 959,620/10 Seigle. An insulating composition is made from a compacted mixture of asbestiform fiber, magnesia, water and gilsonite, pitch or asphalt, by heating to liquefy the hydrocarbon and then immersing the hot compound in the hot liquid.

U. S. P. 967,720/10 Busch. Making electric insulating material by mixing granulated cork with a binder, as pitch or asphalt, while heated, passing the mixture through a series of pressing rolls and cooling during the rolling and while still under pressure.

U. S. P. 973,557/10 Peterson. An insulating composition is formed of fragments of mica pasted together with kaolin, slate and sodium silicate and fired under pressure.

B. P. 9,858/10 Reid. Making a material for electric insulation by treating with paraffin wax or the like an article composed of a mixture of 40–60 parts by weight of finely powdered cork and 40–60 parts of linseed oil which has been subjected to a temperature usual in preparing boiled oil for painters' use for such a time that it becomes viscid and will draw into threads when cool.

B. P. 9,933/10 Sharp. A dielectric filling or insulating composition is composed of pitch which is heated to a fluid condition and to which is added, while hot, a quantity of finely ground whinstone, the whole being mixed together.

B. P. 13,946/10 Thomson-Houston Co. Insulating materials of which the disruptive strength increases with rise in temperature are made from bakelite dissolved in alcohol and paraffin oil dissolved in amyl acetate. The material when dried forms a hard rubber-like mass, and the solution may be applied to fabrics of fibrous material to produce insulating bodies.

B. P. 28,069/10 Thomas. A composition of mica finely ground and washed, resin, and resin or mineral oil, preferably in equal proportions, is used for electric insulation. The mixture is heated and stirred till fluid. On continuing the operation, it becomes thick and again fluid. It may be employed for impregnating fiber, paper, or other material, loose or in fabric or sheet form, which is used as an insulator for cables.

B. P. 28,834/10 Rasmussen. A composition for electric insulating and other purposes, consists, e.g., of mineral caoutchouc 1, ground mica 28, ground asbestos 50, ground serpentine 50, sulphur 9, and shellac 40 parts.

G. P. 244,552/10 Meirowsky. In the manufacture of mica plates, employing a surface adapted to hold the built up plate of small mica flakes and adhesive by suction.

G. P. 247,373/10 Winkler. In making quickly drying masses for protecting and insulating purposes, oils and fats are heated with phenol in the presence of drying agents such as benzol, toluene, xylene or terpentine, using pressure if desired.

U. S. P. 981,178/11 Diesser. Making varnish and insulation material by causing fatty acids as those of linseed oil or wood oil, to react upon cellulose, oxy- or hydro-cellulose or starch, under pressure at a temperature of 280–320 deg., the volatile products of the reaction being allowed to escape.

U. S. P. 985,399/11 Cooper. Flexible insulating tape is composed of outer strips of thin paper, mica sheets between the strips and a binding material between the paper and mica consisting of varnish, methyl alcohol and castor oil.

U. S. P. 1,000,598/11 Hall. Making a fibrous composition for use as heat and electrical insulation, by forming a milky mixture of clay and water, emulsifying oleaginous or resinous material, e.g., hydrocarbon oil, with the mixture, adding a viscous substance (glue) and finely divided fibrous material, such as paper, leaves, peat, or bark, and finally expelling the water.

U. S. P. 1,005,240/11 Leggett. A composition for insulating electric wires consists of lac seed 9 oz., gamboge 24 oz., red gum 6 oz., asphaltum 3 lbs. and Venice turpentine to make 3 gal. of the mixture.

U. S. P. 1,009,035/11 Barringer. Steam-hardened insulating material is formed of silica, slaked lime and asbestos and has a metallic conductor embedded in it.

U. S. P. 1,009,630/11 Barringer. Dense, stone-like molded insulating material contains asbestos and a binder of hydrated calcium silicate, the binder being in excess of any free lime or silica which may be present.

U. S. P. 1,009,731/11 Fisher. Making sheathed insulated cables by driving air and moisture from a core by subjection to a vacuum, flooding it with insulating compound, drawing the core from the compound and simultaneously with its withdrawal surrounding it, to the exclusion of air, with a sheath of lead.

B. P. 5,165/11 Thomson-Houston Co. In making electric insulation a condensation product of phenol and formaldehyde is dissolved in a common solvent such as amyl acetate with a fatty pitch such as that of stearin, cotton-oil, wool-oil, and palm pitch, etc. The saponaceous residue from the purification of oils by caustic soda may be used, and the solution is used as a varnish for dynamo and transformer windings, or for impregnating cambric to render it insulating. The solvent may be evaporated to give a product the resistance of which increases with rise of temperature.

B. P. 9,559/11 Aylsworth. Infusible resins are formed by adding formaldehyde or hexamethylenetetramine to fusible resins which contain a halogen substituted phenol or naphthol, and heating. The product is plastic on heating and may be used for sound records, embossed articles, electric insulators, etc. Naphthalene may be added to the resin to lower the melting point of the halogen phenol used.

B. P. 11,728/11 Doerflinger. Cellulose ester solutions are produced by dissolving nitrocellulose or acetylcellulose or both in diacetone alcohol with or without a diluent or another solvent. They may be used as waterproofing and impregnating media, and for the manufacture of films, filaments, and insulating materials. Solutions of resins and oils in diacetone alcohol may be added to the solutions of cellulose ester.

B. P. 16,143/11 Bastian. A tubular envelope or support for an electric resistance consists of Jena combustion glass, or similar glass, rendered cloudy, or frosted with a sand blast or acid. The resistance may be a spiral wire fitting closely inside the tube.

B. P. 16,810/11 Hartmann. Animal skins for use in making boxes, etc., boats, military equipments, electric insulation, and as a substitute for whalebone and horn, are hardened and waterproofed by steeping them in a bath of amyl acetate and acetone, then coating with a solution of celluloid in amyl acetate and acetone, and finally with an alcoholic solution of shellac.

B. P. 17,803/11 Duda. Willow bark or twigs are steamed or boiled for a short time at a pressure of from 1 to 3 atmospheres and then passed between corrugated rollers to separate the fibers from one another and from the remaining cellular part of the bark. The long fibers are impregnated in tanning products from the bark and used for spinning purposes. The shorter fibers are pressed into blocks with the cellular part of the bark and used as insulating material for heat or electricity, for stuffing-box packing, for pasteboard, etc.

B. P. 21,987/11 Gen. Elec. Co. Powdered talc or soapstone is mixed with gelatinous magnesium silicate, molded under pressure and fired at about 1000–1300 deg. in making an electric insulating composition. The soapstone used may have been previously fired, but it is preferred to use at least some unfired soapstone.

G. P. 271,825/11 Allgem, Elek.-Ges. Making electric insulation as compressed products from the condensation products of phenols and aldehydes by adding to these in the fusible state water-binding compounds such as gypsum and cement

in such amount that the water liberated in the molds by the conversion into the infusible end product, is bound and rendered chemically and electrically harmless.

U. S. P. 1,022,495/12 Muller. Insulating composition made by heating a mixture of asbestos and tar.

U. S. P. 1,025,286/12 Hemming. Insulating composition formed of hard baked asbestos, coal tar pitch and non-volatile residue of anthracene oil.

U. S. P. 1,039,940/12 Hemming. Making an insulating material from hydraulic cement, asbestos and water.

U. S. P. 1,049,005/12 Steinmetz. An electrical insulating composition is made by mixing powdered talc with gelatinous magnesium silicate, molding under pressure and firing at about 1000 deg.

B. P. 521/12 Quick. A plastic composition consists of well pressed yeast 40, ground dried spent hops 30, and pulped fibrous material such as wood pulp or oakum or pulped textile fabric 10. The whole is mixed in the cold, then heated to 140 deg. F. and molded or used hot. Gum or shellac varnish 10 or sodium silicate 10, or both, may be employed as a binder. Vegetable oil 8 may be added to give the composition a waterproof character. It may be used for making slabs, tiles, etc., or as a non-conducting medium or as a plaster.

B. P. 636/12 Scherrer. A mixture of ground naphthalene residues, with or without a small quantity of vegetable oil, and filling materials such as powdered wood, leather, cork, vulcanite, clippings, graphite, balata, or mineral substance, is used for making elastic and other products for electric insulation, etc. The naphthalene residues consist chiefly of the non-volatile sulpho acids obtained in the purification of naphthalene by treatment with sulphuric acid and distillation, and also vulcanization.

B. P. 1,599/12 Collardon. In making plastic compositions, cellulose xanthate which is subsequently converted into hydrocellulose or sulphohydrocellulose, or both, are mixed with just sufficient resinous rubber or the like such as synthetic caoutchouc or polymerized hydrocarbons of the divinyl group to make the final product waterproof and flexible and suitable for electric insulation and other purposes.

B. P. 6,405/12 Gen. Elec. Co. A mixture of a phenol-aldehyde partial condensation product, polymerizable by heat to a final infusible state, and a stable permanently fusible phenol-aldehyde condensation product, may be used for electric insulation and other purposes. The first product is made by heating phenol or a homolog with formaldehyde in molecular proportions in the presence of a base such as soda or ammonia, and separating the viscous from the watery layer. The fusible product is made in a similar way by using an acid condensing agent. Water is added to control the reaction. An example of proportions is: 1120 cc. 90% phenol solution, 800 c.c. 40% formaldehyde, 120 c.c. hydrochloric acid, and 8000 c.c. water. A molded product with asbestos or like filler is made by mixing 25–30 parts of solid polymerizable or other fibrous material.

B. P. 16,616/12 Diesser. The products such as films, etc., obtained from formic acid solutions of albumens have their elasticity increased by treating them, or the solutions from which they are produced, with formaldehyde, with or without triacetin, diethylaniline, etc.; the solutions may be used for impregnation purposes, and the films, etc., for electrical insulation.

B. P. 17,544/12 Rowe. Peat-moss is dried and mixed with pressed brewers' or liquid yeast, and the mixture is dried, formed into cakes, crushed, passed through rollers or mixed with flavoring, coloring, or other materials, according to desired use. It may be used as a fodder, fertilizer, insulating material, in oil-cloth or linoleum manufacture, for making plaques for wall decoration, or as a substitute for straw-board or mill-board.

B. P. 21,943/12 Kelly. A mucilage is formed by mixing a gummy resin, such as that from which turpentine is distilled, with an equal quantity of a non-drying

vegetable oil. An insulating and waterproofing composition is produced by adding 10.3% of this mixture to oils such as linseed or tung oil, to which glycerol has been added, and heating quickly to about 550 deg. F. Fabric, paper, or like material is dipped in this compound and dried. A glue is made by adding 2.3% of a mixture of 3 parts of a cement such as Portland, and 1 part of a metallic oxide.

B. P. 23,846/12 Kelly. An elastic composition is obtained by mixing colloidal materials such as size or gelatin with oils or fats consisting of glycerides, or with mineral oils and glycerides, or with mineral oils and glycerol, and then adding metallic oxides such as those of lead, zinc, or iron, and Portland or magnesian-limestone cement, and subjecting to heat. A soft composition is obtained by heating 5 parts by measure of size, 3.5 of glycerides, 2 of cement, and 0.5 part of a metallic oxide to a temperature of about 212 deg. F. The composition is waterproof and of an insulating nature.

F. P. 447,086/12 Dubois. In the manufacture of hard coherent asbestos articles, ordinary asbestos is mixed with magnesia 10–20% and molasses (5% sugar) 10–15%, the mass is kneaded and pressed in the moist state in forms. After protracted drying, the product is dipped in water-glass of 10 deg. Beaumé, whereby the silicates are decomposed by the potassium salts and the like contained in molasses. The products are hard, waterproof and insulating.

F. P. 451,581/12 Magelssen. In making an insulation, incombustible, non-hygroscopic shells, filled with insulating material such as turf, cork, etc., are formed by mixing chalk, asbestos, water-glass, and acid, and forming the thin plates (about 1 mm. in thickness) into corrugated sheets.

F. P. 452,671/12 Hohn. A cement for insulating bodies of porcelain and iron, also for cement, consists of equal parts of syrian resin (melting at 140 deg.) and cement, fused together.

F. P. 457,743/12 Grote. In the manufacture of an adhesive and binding material, formaldehyde (10–40%) is heated with potato starch, combined with hypochlorites, magnesium chloride, etc., and, after the addition of hot fish glue, resin, hard pitch, cellulose solutions, and the like, the product is employed as a permanent binding agent for insulating materials, compressible in the cold.

G. P. 263,400/12 Sening. In the manufacture of a non-hygroscopic insulating material from magnesia cement, finely divided mica is added, at the room temperature, to the mixture of the known initial materials, magnesia and magnesium chloride, beside the known fibrous material for imparting elasticity to the product. The mica combines with the magnesia cement to a very solid mass, but very slightly hygroscopic, a good insulator, and, in 10 mm. thickness, insulating against a voltage of 15,000.

G. P. 270,133/12 Westinghouse Elec. Co. Manufacture of insulating plates from mica and a powdered binding agent.

G. P. 291,313/12 Boehm. Unglazed, previously burned high tension insulators, which are porous, are impregnated with highly insulating material, such as paraffin, caoutchouc, oils and the like. The insulators are preferably preheated, and evacuated. By a suitable after-treatment as by means of ozone, the heavy hydrocarbons can be fixed in the insulator. Other highly insulating substances, such as mica powder, may be worked into the insulator in a liquid vehicle such as molten paraffin.

G. P. 294,758/12 Boehm. Addition to 291,313. The principal process is modified in that the porcelain material which is saturated with highly insulating substances consists of ground ceramic substances burned at a high temperature in order to secure a porosity and at the same time marked strength. Binders are employed which upon vaporization or fritting, increase the porosity.

U. S P. 1,049,918/13 Rice. Insulating material for electrical commutators, consists of layers of "commutite" and mica.

U. S. P. 1,064,893/13 Dreher. Electrical insulating material is formed of kaolin 46%, powdered glass 7%, powdered slate 17%, and asbestos 30% formed into sheets, soaked in sodium silicate solution, compressed and fired.

U. S. P. 1,065,802/13 Hammesfahr. Fireproof and waterproof insulating for wire, containing blown glass, crushed to a matted flocculent condition, and a binder such as shellac.

U. S. P. 1,067,851/13 Trotter. An electrical insulating composition is formed of stearin pitch which is heated for several hours at about 175 deg. and then cooled to about 115 deg. and thoroughly mixed with about 20% manganese dioxide.

U. S. P. 1,083,168/13 Whipple. A compound for electrical insulation, etc., is formed by heating moist resin to about 135 deg., passing moist air through the molten mass, heating the residue to about 140 deg. and passing dry air through it. The complex turpentine products are broken up and volatilized together with volatile organic acids.

U. S. P. 1,083,169/13 Whipple. A soft, gummy resinous product for use in electrical insulating, etc., which is non-drying, permanently plastic, non-oxidizing, of high electric resistance and sp. gr. about 0.98, is made by the process of the preceding patent.

B. P. 3,434/13 Electro-Osmose. Ges. Ceramic articles, such as electric insulators, are made from material which sinters and melts at the same temperature, such as soapstone, steatite, or like magnesium silicates, the sintering temperature being lowered by fractionating the material in colloidal form before it is molded and burned.

B. P. 3,566/13 Gen. Elec. Co. Products for molding, electric insulation, varnishes, etc., are formed by heating a polyhydric alcohol (glycerol, glycol, etc.) with an excess by weight of succinic acid, tartaric acid, or pyrotartaric acid. Part of the acid may be replaced by a polybasic acid of the aromatic series or by its anhydride, such as phthalic anhydride. Molten resin may be added. Varnishes may be prepared by dissolving some of the products in acetone, and fibrous or cellular materials may be impregnated with the solution and hardened by heating.

B. P. 8,417/13 Gen. Elec. Co. When impregnating for electric insulation with resinous condensation products of a polyhydric alcohol, such as glycerol, and a polybasic acid or anhydride, like phthalic anhydride, these are kept from hardening while in the fused state by the addition of naphthalene, anthracene, phenanthrene, or other hydrocarbons of the aromatic series or their substitution products. The impregnation of fabrics wound on electric coils and of cotton, paper, and similar material is mentioned.

B. P. 13,657/13 McCoy. In making resinous compounds, phenols are condensed with sulphur chloride (or its oil compounds) in the presence or absence of a solvent, and the product is treated with formaldehyde. To the plastic mass may be added, before heating, solvents such as camphor or glycerol, to render it permanently plastic, and nitrocellulose or rubber may be added as fillers. Other fillers such as asbestos, silica, wood flour, mica, etc., may also be used. The mass is rendered insoluble by subsequent heating and the product has electrical insulating properties.

B. P. 26,716/13 Bull. A fire and oil resisting and electrical insulating composition is made from dried and ground skins, sinews, hoofs, etc. The animal matter is dried and ground, and to it is added about 10% of fine wood pulp, and 10% of asbestos. To this is added 1% of asphalt, pitch, etc., and 20% of a liquid made up of equal parts of water, animal or vegetable oil or fat, and fresh blood, and the whole is mixed. It is molded while warm under high pressure.

F. P. 453,464/13 Soc. Debauge & Cie. In making an insulating agent for cables from cellulose impregnated with cellulose acetate, the bands and threads of paper-stock, cotton, jute, etc., to be used for winding the conductor, are im-

pregnated with cellulose acetate, and the whole is coated with plastic masses obtained from cellulose acetates.

F. P. 464,579/13 Kelly. In making plastic or flexible insulating material which is waterproof and unaffected by comparatively high temperatures, a mucilage is prepared by mixing gummy resins extracted from ligneous or cellular materials with an equal amount of a non-drying oil. From 10 to 30% of this mucilage is added to an oil containing glycerol, the temperature is raised rapidly to about 176 deg., and then the mass is allowed to cool.

G. P. 276,363/13 Meusel. Colloidal linseed oil and colloidal castor oil (obtained by heating the oils with fine metals, according to 258,900/12) are mixed, dried and rolled into thin, elastic layers. It is waterproof and comparatively gas-tight, and is used as a floor, wall and furniture covering, as packing in machines, for tires, insulating, etc.

G. P. 280,099/13 and U. S. P. 1,123,985/15 Bolling. Making an electrical insulating material by mixing mica flakes with a ceramic flux containing boron, silicon and lead and heating the mixture to 500–950 deg. C. and compressing it.

G. P. 287,276/13 Knofler. Addition to 285,934. The products of the principal process (refractory vessels from the rare earths, also from the oxides of thorium and zirconium) are made impermeable to molten thorium and cerium oxides with the addition of alumina, silica, titanium, or the like. These vessels are but slightly, if at all, electrically conductive at the highest temperatures.

Swiss P. 64,329/13 Ledergerber. In the production of an electrically insulating coating on wires, the wires of any metal, are passed through a mass containing celluloid and acetone and the excess is wiped off.

U. S. P. 1,083,354/14 Edison. An insulating material containing tetrachloronaphthalene 6 and asphalt 1 part, is used for coating containers for storage battery cells, wires, armatures, etc.

U. S. P. 1,083,755/14 Peabody. Electrical insulation is formed of paper pulp by beating with at least 3 oz. of resin to each lb. of dry fiber used, the ingredients being thoroughly mixed by heat and pressure, and then dried. Phenol resins, shellac or manilla gum may be used instead of resin.

U. S. P. 1,085,102/14 Barringer. Making a hard machinable electrical insulating composition by mixing zinc oxide 20 with sulphur 8 and linseed oil 15–20 parts, holding the mixture and heating it to about 150–220 deg., when the zinc oxide and oil react and form a hard, porous mass, the pores of which are filled with the reaction product of the sulphur oil. Inert fillers such as ground flint, talc or asbestos may be included.

U. S. P. 1,091,521/14 Barringer. An electrical insulating composition is formed of a condensation product of phenol with formaldehyde, 50 parts, stearin pitch from cottonseed oil refining 30, and amyl acetate 200 parts, with a fibrous carrier such as cambric. The insulation remains flexible indefinitely and its resistance increases with rise in temperature up to 75 deg.

U. S. P. 1,091,620/14 Barringer. A composition for electrical insulation consisting of asbestos, hydrous calcium silicate and calcium stearate is made by heating a moist mixture of slaked lime 60, powdered flint 20, and asbestos 20 parts with steam under 150 lbs. pressure and treating the product with stearic acid. Instead of the latter rosin oil or oleic or palmitic acid may be used.

U. S. P. 1,091,627/14 Callahan. A resinous composition for electrical insulation, varnish, etc., is formed by heating glycerol and malic acid in molecular proportions to about 235 deg. The product is soluble in acetone and fusible at 100 deg., but is rendered insoluble and infusible by prolonged heating at 90–135 deg. or by quickly heating to 270 deg.

U. S. P. 1,091,678/14 Locke. An electrical insulating composition is formed by fusing together clay or feldspar 100 and borax, boric acid or colmanite 5–100

parts. It is tougher and more resistant to changes of temperature than glass and has a greater electrical resistance.

U. S. P. 1,091,725/14 Barringer. An electrical insulating composition is formed of copal 70–85, castor oil 5–15 and rubber resin 5–20 parts.

U. S. P. 1,091,732/14 Callahan. Tough, flexible resinous products for electrical insulation or varnish, etc., are formed by heating glycerol with about twice its weight of succinic acid at 220 deg., until a sample on cooling is tenacious and sticky. Citric or tartaric acid and glycol may also be used to obtain a similar product, which is soluble in acetone and becomes insoluble and infusible after heating at about 85 deg. for 15 hours.

U. S. P. 1,092,178/14 Locke. Electrical insulation formed by fusing together silica 100 and boron or a boron compound such as borax, boric acid or colmanite 1–60 parts.

U. S. P. 1,092,511/14 Aylsworth. Making an electrical insulating composition by pulverizing an infusible phenol condensation product free from uncombined phenol, treating it with hot caustic soda or potash solution, washing, mixing with caoutchouc and sulphur, vulcanizing by heating, and treating with caustic alkali to remove excess of vulcanizing agent and uncombined reaction products.

U. S. P. 1,094,505/14 Whitney. Purifying commercial asbestos to remove impurities such as magnetite and improve its efficiency when used in fabrics for electric insulation, by treating it with a dilute solution of oxalic acid and then washing with water.

U. S. P. 1,094,829/14 Aylsworth. A liquid electrical insulating mixture contains chloronaphthalene and dissolved stearic or palmitic anhydride; free from water, naphthalene and higher substitution products.

U. S. P. 1,096,838/14 Hayden. Electrical insulation formed of a sheet of fibrous material impregnated with a phenolic condensation product and paraffin oil dissolved in alcohol and amyl acetate.

U. S. P. 1,098,776/14 Arsem. A composition for varnish, electrical insulation, etc., is made by heating glycerol, phthalic acid and succinic acid in the molecular proportions of 2, 2 and 1, respectively, until a jelly-like mass of mixed ester is formed. The material is tough, fusible and soluble in organic solvents and may be converted to an insoluble, infusible condition by further heating.

U. S. P. 1,098,777/14 Arsem. A resinous condensation product for varnish, insulation, etc., is formed by heating a mixture of glycerol and phthalic anhydride in about equi-molecular proportions to 200–210 deg. until combination takes place and then adding ¼ mol. proportion of phthalic anhydride and ½ mol. proportion of oleic acid and heating at about 200–230 deg. to form a flexible, fusible, soluble product which may be rendered infusible and insoluble by heating to 160 deg. for 30 hrs.

U. S. P. 1,098,967/14 Peterson. Sheets of insulating material from mica.

U. S. P. 1,101,281/14 Holmes. Electrical insulation material is formed by the destructive distillation of a mixture of ozocerite, asphalt and castor or cotton-seed oil.

U. S. P. 1,102,633/14 Aylsworth. An electrical insulating composition is formed of manilla gum 100, phenylphthalimide 20–70, and castor oil 10–30 parts.

U. S. P. 1,103,285/14 Hadley. An electrical insulating composition is formed of coal tar 8 gals., kerosene oil 2 gals., Portland cement 2 gals., and Japan drier 1 gal.

U. S. P. 1,108,332/14 Callahan. A tough, resinous condensation product for electric insulation is formed from glycerol 184, succinic acid 141 and phthalic anhydride 118 parts, by heating to 85–150 deg.

U. S. P. 1,119,441/14 Menningen. An electrical insulating composition is formed of a mixture of sand and hydraulic cement 5, asbestos 3 and shellac 4 parts.

U. S. P. 1,119,442/14 Menningen. Electric insulation is formed of hydraulic cement 5, asbestos 3 and shellac 4 parts.

U. S. P. 1,119,592/14 Friedburg. Making a plastic material for electrical insulation by dissolving 22 parts of a reaction product formed by heating glycerol 1 and phthalic anhydride 2 parts to 185–210 deg., adding butyric acid 10 parts, heating for 8–24 hrs. and finally distilling off the uncombined ingredients.

U. S. P. 1,120,951/14 Locke. An electrical insulator for high potential line wires, etc., is formed of a porcelain base fused together with boric acid or some other boron compound.

B. P. 1,133/14 Rowley. An electric and heat insulating material is made from silk cotton, such as kapok, raw fiber, and the fibers of bombax malabaricum and gallotropis giganeta, which are compressed and may be mixed with other materials or mounted upon a strengthening base, such as a slab of slate. In the latter form, it may be used in electric switches.

B. P. 9,370/14 Campbell. A plastic composition of comminuted leather, animal fat, fatty oil, or resin oil, or a combination of these, together with powdered filling material, such as magnesite, lime, and French chalk, and a resilient vulcanizable binder, is used for making leather and rubber substitutes and waterproof and electric insulating materials. It may be combined with a vulcanizing agent, such as sulphur, with tannic acid and bark extract, or it may be dissolved and applied to a canvas or other backing, and the vulcanizable binder may consist of Jelutong, rubber, gutta, balata, rubber waste, etc. Potassium bichromate, borax, and metal dust may also be added.

B. P. 20,409/14 and **U, S. P. 1.183,640/16 Grossmann.** A fusible insulating and filling material for electric purposes and adapted to be sold in powdered form consists of a mixture containing 45% of colophonium, 45% of gypsum, and 10% of paraffin wax.

B. P. 23,345/14 Guise. Plastic composition made by mixing together 55 parts of burned magnesite, 15 parts of burned and ground China clay, 15 parts of quartz, 10 parts of asbestos, and 5 parts of wood meal, the dry powder being mixed first with magnesium chloride solution of 16–36 deg. Beaumé and then with paraffin oil (one gallon chloride to one pint oil). Cork, powdered glass, slag, crushed sea shells, or carborundum may be added. The composition may be employed for paving floors, etc., for switchboards, electric insulations, table tops, etc., and for assembling porcelain insulations with metal parts, also for uniting stone, metals, wood, glass, and leather.

B. P. 24,419/14 Gen. Elec. Co. Molding compositions for electric insulation are made by mixing 15 parts of asbestos, 74 of ground marble, 10 of thickened Chinese wood oil, and 1 of carbon black, and heating to solidify the oil.

F. P. 468,241/14 Regal. In making plastic masses for insulating purposes, the condensation of phenols 2 parts with formaldehyde 1 part is effected in the presence of substances such as water-glass 0.5–1 part, or sodium aluminate or zincate, together with soda 0.2 parts, which act both as condensing agents and as precipitants of silica, alumina, etc.

G. P. 285,967/14 Heide. In waterproofing polished surfaces, porous stone and insulating masses, the surfaces are sprayed with an aqueous liquid, consisting of ammoniacal zinc solution and soap. About 60 parts of ammonium or alkali soap are dissolved in 1000 of water, if necessary, with some alcohol. A solution of about 8 parts zinc hydroxide in 100 of ammonia solution of sp. gr. 0.90, is mixed with 900 parts water, and this is mixed with the solution first prepared. The soaps are prepared preferably from purified oleic acid.

G. P. 289,024/14 Siemens-Schuckert-Werke. Electric machines and apparatus are insulated with asphalt masses which are liquefied by heating or dissolving or both and sprayed upon the articles.

U. S. P. 1,127,042/15 Locke. Electrical insulator for high potential line conductors is formed of glass fused with 1% or more of boric acid which renders the glass capable of withstanding a 25% higher voltage than without the boron compound.

U. S. P. 1,127,044/15 Locke. Electrical insulator for high potential line conductors, formed of silica fused with 1% or more of boric acid or borax, which increases its resistance to puncture by high voltages about 25%.

U. S. P. 1,136,504/15 Brookfield. Making a non-crystalline tough glass mixture for insulators, etc., by mixing pulverized glass or cullet with about 30% its weight of clay with or without lime and fusing the mixture to a homogeneous mass.

U. S. P. 1,138,676/15 Longmore. Making electrical insulation in sheet form by collecting a shower of mixed mica scales and shellac or other binder upon a heated plate and subjecting the layer thus formed to pressure beneath another heated plate.

U. S. P. 1,138,691/15 Sanborn. Electrical insulation in sheet form is made by allowing mica flakes and powdered shellac to settle through a tall chamber filled with air and heating and pressing the layer of the mixture which collects on the floor of the chamber.

U. S. P. 1,141,944/15 Dawson. An electrical insulator is made from a mixed glycerol ester of phthalic and oleic acids mixed with castor oil; formed by heating to 200 deg. C. glycerol 92 with phthalic anhydride 148 parts, adding oleic acid 70.5, castor oil 70.5 and phthalic anhydride 37 parts. It is a flexible, reddish, resinous material which on heating to 160 deg. C. for 15 hrs. is rendered insoluble and infusible.

U. S. P. 1,144,395/15 Thomas. Vitrified bricks, tiles and insulators are made by mixing sand 66 with glass 34 and water 6 parts, pressing the mixture into clots, drying successively under oxidizing and reducing conditions at 980–1150 deg. C. and then pressing the clots into their final form without greatly reducing their volume.

U. S. P. 1,149,171/15 Baeder. Insulating varnish is formed of raw linseed oil 100 gals., refined Para rubber 25 lbs., manganese borate 10 lbs., calcined sugar of lead 75 lbs., and turpentine 50 gals., mixed with additional thinner and Japan drier.

U. S. P. 1,153,975/15 Thomas. An electrical insulating mixture is formed of equal amounts of ground mica (washed free of salt or alkaline substances), resin and resin oil.

U. S. P. 1,156,452/15 Baekeland. An insulating composition for impregnating electric coils, immiscible with water and having high dielectric properties is prepared by mixing a solid initial condensation product of phenol and formaldehyde with about 30–40% its weight of naphthalene or similar solid solvent and about 15–30% of a liquid solvent of high boiling point, e.g., nitrophenol, nitrotoluene, xylene, toluene or cumene.

U. S. P. 1,165,164/15 Ferla. For electrical insulating material a mixture of cement, hemp, acetic acid, and glue is impregnated with linseed oil or other drying oil and baked.

U. S. P. 1,170,000/16 Robinson. Electric insulation is formed on wires, etc., by application of one or more coats of walrus or whale oil which are heated to 500 deg. to harden them. The coating will withstand heating to 650 deg. without carbonizing.

U. S. P. 1,160,362/15 Baekeland. For electrical insulation paper pulp is beaten with a phenolic condensation product capable of transformation into infusible form by heating, and after thorough mixing the product is pressed into form and heated. 15–50% of condensation product is used. Knife handles, buttons, etc., may also be made.

U. S. P. 1,160,363/15 Baekeland. Hydrated cement or plaster tiles, etc., are coated with a phenolic condensation product and heated to 160–200 deg. C. under 80 lbs. pressure to render them waterproof. Electric insulators may be made of plaster of Paris, asbestos, magnesia and phenol condensation product.

U. S. P. 1,162,092/15 Menningen. In making electric insulating composition a mixture of sand 5, asbestos 3 and shellac 4 parts with a solvent is molded under pressure while heated, then heated without pressure to compact the somewhat shrunken article.

B. P. 431/15 Soc. Combustibles. An electric or heat insulating material, used for coating or impregnating permeable supports such as paper, cloth, etc., is formed by oxidizing the heavier portions of coal tar and petroleum distillation products in a current of hot air until a stable plastic mass results.

B. P. 3,364/15 Richards. An electric insulating material, suitable when in the form of slabs for tanks, cisterns, and other purposes, is formed by molding the articles in Portland, Roman, or other cement, with or without an admixture of asbestos or other fiber. The articles, after drying, are impregnated with the pitch-like residuum (from tar oils) described in 3,008/12.

B. P. 4,820/15 Sharp. A dielectric composition for filling troughs, conduits, etc., for electric cables, consists of spent shale and a binding agent, such as pitch or bitumen, e.g., in equal quantities by weight.

Can. P. 160,187/15 Barringer. A dense insulating composition comprising sulphurized oil, saponified oil and a fossil gum.

G. P. 280,821/15 Weidinger. Addition to 273,132. Insulating plates are prepared from feldspar and mica, or from either of these alone instead of from the three constituents of granite as specified in the principal patent. Also instead of a solution of caoutchouc in turpentine, a solution of other high melting colloids, such as asphalt, may be employed. In this case no water is needed.

U. S. P. 1,175,424/16 Freeman. Electrical insulation is made from waste sulphite liquor by concentration and treatment with common salt and barium chloride, drying with the precipitate, and mixing with magnesia, magnesium chloride, powdered glass and a small amount of a hard gum or resin.

U. S. P. 1,179,229/16 Shartel. Pliable sheets suitable for use in electric insulation, hat stock or wall coverings are prepared from the trunk, limbs or roots of the Joshua palm yucca by macerating with caustic alkali and pressing.

U. S. P. 1,180,902/16 Bonner. A pliable material suitable for impregnating textile fabrics to form a leather substitute, for making electric insulation and for other purposes, is made from commercial oleic acid (''red oil'') treated with a solution of caustic soda in excess of that required to neutralize the acid and combine with carbon disulphide to form a colloidal solution. The latter is coagulated by standing for some time at 27–32 deg. or by heating to about 100 deg. for a shorter time. Other fatty oils, e.g., linseed oil, give similar products with carbon disulphide and caustic soda or potash, or anhydrous ammonia.

U. S. P. 1,181,800/16 Randolph. An insulating composition for electric heaters is formed of granular silica 90–95% and boron oxide 5–10%. Benzol may be used to facilitate mixing the ingredients.

U. S. P. 1,183,423/16 Aylsworth. Solid chlorinated naphthalene is oxidized by heating with concentrated nitric acid, the product is treated with caustic alkali to break up unstable addition products and washed with water to remove the alkali salts. A tough, flexible and practically non-crystalline insulating material is obtained.

U. S. P. 1,190,815/16 Tazewell. Molded insulators against electricity and heat are formed of creosote oil 8, shellac 8, sufficient short-fibered asbestos to serve as a thickener, alum 0.5 part and varying amounts of magnesite, rosin, slaked lime, or pigments.

U. S. P. 1,196,505/16 Aylsworth. For electric insulation a mixture of chloronaphthalenes with a chlorine content at least equal to that of trichlornaphthalene is mixed with a small amount of lime, barium oxide or sodium hydrate and distilled to eliminate all hydrochloric acid from the composition.

U. S. P. 1,196,693/16 Hyde. Sandstone is treated with linseed oil to fill its interstices and harden and toughen it for use as an electric insulation or for other purposes.

U. S. P. 1,197,171/16 Aylsworth. Phenol is caused to react with formaldehyde in the presence of sulphuric acid and in sufficient amount to form an infusible product, and after partial reaction the mass is mixed with barium carbonate to combine with all the acid present, forming barium sulphate. The product is suitable for electric insulation.

Swiss P. 72,678/16 Martin. An insulating mass consists of molten crystallized alumina united by a binder to a solid body.

Swiss P. 73,854/16 Borel. Concrete or cement is dried first slowly in air, then rapidly in heated stoves, and then impregnated with an insulating substance.

Jap. P. 30,141/16 Hotta. An insulating acid and water proof paint is prepared by mixing together varnish, powdered whetstone, aluminum acetate, calcined gypsum, litharge, powdered mica, some mineral powders, asphalt, boiled oil and a diluent.

U. S. P. 1,213,144/17 Baekeland. An electric insulating composition adapted for impregnating coils is formed of a mixture of asbestos (or other substance which gives flexibility to the final product) with a phenolic condensation product which is initially fluid and mobile but which on heating is transformed, without material change in volume, into infusible solid form.

U. S. P. 1,217,873/17 Marshall. An insulating lining for lamp sockets is formed of an asbestos tube impregnated with the reaction products of linseed oil 30–70% and a soluble silicate 70–30% by oxidizing and baking at a temperature of about 200 deg. or slightly higher.

U. S. P. 1,225,147/17 Locke. A glass for electrical insulators, having a coefficient of expansion less than 0.0000050, is formed of silica 80, cryolite 17, and boric acid 3 parts. The glass is highly resistant to sudden changes in temperatures.

U. S. P. 1,226,816/17 Schoenmehl. Insulating block for primary electric battery elements.

U. S. P. 1,226,008/17 Locke. Insulators for electric currents of high voltage are formed of the product made by fusing together borax or boric acid, silica and cryolite.

U. S. P. 1,227,465/17 McCoy. Shellac is dissolved in a 5% solution of borax, caustic soda or potash, or other weak alkali solution and a concentrated solution of tannic acid is added which precipitates the shellac together with an alkali metal tannate. This mixed precipitate is filtered out and washed and may then be molded for electric insulation or other articles, alone or with the addition of ground asbestos, wood flour or other fillers. Similar products are obtained by using, instead of shellac, copal or other natural resin or a synthetic resin of the bakelite type. These products do not require heating when molded.

U. S. P. 1,233,415/17. An electrical insulating composition is formed of about equal amounts of coal tar pitch and stearin pitch mixed with castor oil and a volatile solvent such as benzol. 1,233,416/17 describes a similar composition.

U. S. P. 1,233,486/17 Locke. An electrical insulating composition for high voltages, with a coefficient of expansion of less than 0.0000056, is formed by fusing together silica 70–75, alumina 0–5, boron oxide 13–28 and lithium oxide 1–9 parts. Nitrates of sodium and potassium may be used as fluxes.

U. S. P. 1,240,565/17 Harris. An insulating material for wires is formed by heating a mixture of resin and castor oil to a temperature of 250–310 deg. until

about 5–15% of the decomposition products of the castor oil have been distilled. The product is applied at a temperature of about 300 deg.

U. S. P. 1,240,566/17 Harris. A hard, elastic, enamel-like, insoluble, electrical insulation is made by heating in the form in which the final product is desired, a mixture of castor oil and a metal soap of castor oil, e.g., the soap formed from castor oil and oxide of copper, iron or aluminum at a temperature of about 300 deg. which effects polymerization and partial destructive distillation.

U. S. P. 1,240,567/17 Harris. Insulation similar to that of the preceding patent is formed by heating a mixture of castor oil and resinate of copper, calcium or other metal at a temperature of 250–310 deg.

U. S. P. 1,241,926/17 Cordes. Hydrogenated castor oil is used as an impregnating material for telephone condensers. It has a higher insulating capacity than paraffin.

U. S. P. 1,245,976/17 Satow. Proteins derived from soy beans or other vegetable material are glutinized with a solution of malic or other acid, and then treated with formaldehyde or hexamethylene tetramine to form a celluloid-like product which may be used for making molded electric insulators or other articles.

U. S. P. 1,245,980/17 Satow. An electric insulation is formed by glutinizing vegetable proteins with phenol and combining the glutinized mass with formaldehyde, trioxymethylene or hexamethylene tetramine, evaporating to dryness in vacuo and molding under pressure at a temperature of 110–115 deg. Dyes, pigments or fibrous materials may be incorporated.

U. S. P. 1,245,984/17 Satow. A composition suitable for floor coverings, insulation, or as a rubber substitute, is formed by glutinizing vegetable proteins with creosol and oxidized castor oil, and acid or other glutinizing material and mixing this product with sodium hydrate, triphenylglycerol, hydrocellulose, oxycellulose, cellulose esters, formaldehyde, trioxymethylene, hexamethylene tetramine, dyes, pigments, or leather waste or other fillers or modifying agents.

U. S. P. 1,246,809/17 Ellis. An insulation suitable for coating wires is formed of chlorinated asphaltic petroleum oil which may be used alone or with chlorinated fish oil, chlorinated naphthalene, waxes, chlorinated waxes, asphaltic oils, rubber or cotton fabric. U. S. P. 1,246,810 specifies a similar insulation formed of paraffin, ceresin wax, Japan wax or other waxy substance which has been treated with chlorine and a large amount absorbed. The free hydrochloric acid formed is removed by treatment with soda or slaked lime.

U. S. P. 1,248,638/17 Ellis. A flame-proof flexible electrical insulation is made from wax, asphalt or similar combustible organic insulating material by mixing with chlorinated hydrocarbons derived from solvent naphtha. This composition is suitable for use on copper wire.

B. P. 105,573/17 Felten & Guilleaume Akt.-Ges. Submarine telephone cables are insulated by gutta-percha which has been partly or wholly deprived of resin and mixed with natural rubber or its synthetic substitutes. As much as 75% of Ceylon rubber may be added.

B. P. 111,946/17 Jackson. Fibrous pulp in a moist condition is mixed with a glutinous or gelatinous substance, such as gum, starch, or glue. The mixture is heated, compressed, and dried. The pulp may be acidified and glycerol also may be added. The product may be used for electric insulation and as a substitute for vulcanized fiber, vulcanite, etc.

B. P. 115,946/17 Charlton. Alkali is removed from feldspar by digesting 30–60 parts with 60–30 parts of lime in 300–500 parts of water at 200 lbs. pressure and 160–200 deg. for 2–4 hrs. The insoluble residue is mixed with sand or other rock material, molded, and steamed to form bricks, artificial stone, electric insulators, etc.

B. P. 117,676/17 Chivers. Electric insulating composition consists of asbestos

50%, sulphur 25% and antimony sulphide 25%. The ingredients are incorporated by heating and are afterwards ground up and molded under heat and pressure.

B. P. 139,226/17 Seymour. An electric conductor or cable is provided with a protective and insulating covering which is substantially rigid when cold but readily pliable when warmed, whereby the cable can be laid against irregular surfaces by heating it at the necessary parts. There is used, for example, rubber 35 parts, reclaimed rubber 15, rubber substitute 5, ebonite dust 10, silica 10, magnesia 10 and sulphur 15. After this composition has been applied to the bare conductor, it is vulcanized and forms a covering similar to vulcanite, ebonite, etc.

Holl. P. 2,187/17 Regal. A plastic mass for insulating purposes is made by allowing formaldehyde to act on phenols in the presence of water-glass or other salts which produce, during condensation, finely divided inorganic precipitates.

Jap. P. 31,500/17 Sumitomo. Bare copper wire is treated with an oxidized oil and covered with a mixture containing crude rubber 35, litharge 3, zinc dust 30, talc 30 and trinitrobenzene 2 parts. The covered wire is then heated under pressure without vulcanization.

Swed. P. 42,625/17 Soberg. An insulating product is made by mixing together soapstone, resin and linseed oil.

U. S. P. 1,255,139/18 Cushing. An electric insulating composition suitable for molded and baked articles is formed of asbestos and a binder composed of a varnish of East India gum, China wood oil, and rosin and an oxidation retarder of stearin pitch and coal tar pitch.

U. S. P. 1,255,618/18 Lepine. A non-inflammable liquid composed of pentachlorethane 80, pentachlorbenzene 18, carbon tetrachloride 2 and toluidine 1 part is used for insulation in oil-break switches, electric transformers and other similar devices.

U. S. P. 1,262,305/18 Champion. An insulating material adapted for use in making spark plugs is formed by molding and firing a mixture for plastic uncalcined clay 60%, feldspar 10%, and a non-plastic mixture of calcined clay and flint 30%.

U. S. P. 1,267,696/18 Richards. Electric insulators for use on lines of relatively high voltage are formed of cement impregnated with the pitch-like residuum obtained by distillation from the lighter fraction of tar which has been acidulated and separated from heavy oils and insoluble pitch-like substances.

U. S. P. 1,268,031/18 McCoy. A moldable electric insulating composition is formed of comminuted asbestos 90, China wood oil 10 parts and a small amount of coal tar pitch. The China wood oil is polymerized by heating the mixture in molds.

U. S. P. 1,267,883/18 McIntosh. An electric insulation suitable for use with railway tracks is formed by impregnating parchmentized fiber with acetone and then with linseed oil or other similar oxidizable oil, treating the fiber with hot water or steam to render it flexible and then subjecting it to heat treatment for 12–36 hrs. to effect oxidation of the oil and hardening of the product.

U. S. P. 1,274,728/18 McCoy. Molded articles of high dielectric strength are formed with tannins or tannates as a binder either by hot or cold molding processes. For cold molding, tannins soluble in water are preferably employed together with basic fillers such as lime or magnesia which are capable of combining with the tannins to form compounds insoluble in water. If the product is formed by hot molding, oak bark or similar tannin-containing material is ground and the resulting powder is molded under heat and pressure, either alone or with the addition of fillers such as wood flour, ground asbestos or magnesite. Gelatin, albumen or other organic colloids may be coagulated by the action of tannins and then molded with fillers. Insoluble waste of tanning liquors (phlobaphenes or reds) may also be molded hot with a filler.

U. S. P. 1,274,411/18 Halbleib. An incompletely cured phenolic resin is used

as a binder for the bars and core of commutators, the curing of the resin being finished by heating after the commutator members are assembled.

U. S. P. 1,284,295/18 O'Conor. Composite tubes for electric insulation are formed of wound sheet material such as paper treated with a phenolic condensation product. The outer turns are treated with shellac varnish to give the tubes greater strength. The assembled sheet material is wound upon a mandrel and heated to at least 90 deg.

U. S. P. 1,284,432/18 O'Conor. Sheets of paper, muslin, or other fibrous material are treated with a phenolic condensation product and superposed, subjected to heat and pressure, and during the last stage of this treatment the heat is increased and the pressure lowered. This produces a product suitable for electrical insulation.

U. S. P. 1,284,644/18 Frederick. A decorative insulating material is formed by building up a laminated body of differently colored sheets of paper or other fibrous material and phenolic condensation product; it is shaped, and while held in the form is subjected to heat and pressure simultaneously.

U. S. P. 1,285,057/18 Moore. Forming dielectric material from cloth, paper, wood or other porous material, by moistening with water and then impregnating with a waxy substance, e.g., asphalt, heated above 100 deg.

U. S. P. 1,285,889/18 Anderson. An insulating composition for cables consists of powdered talc 50, resin 4 and linseed oil 10%. Shellac also may be used as a binder.

U. S. P. 1,286,043/18 McCulloch. Electrical insulation for use in heating apparatus is formed by coating flakes of mica with bentonite and water, and pressing and drying.

U. S. P. 1,286,370/18 McCoy. Coal tar pitch is heated to drive off its more volatile constituents, preferably at 260–300 deg., finely divided, treated with benzol or other liquid which will swell and soften the material, and molded under pressure. The product is used as a binder for electrical insulation with fillers such as wood flour or asbestos.

U. S. P. 1,286,372/18 McCoy. A material suitable for electrical insulation is formed by mixing about equal parts of pyrogallol and gum arabic with about 5% their weight of trioxymethylene and about 50% of a filler such as sawdust, asbestos or wood flour, and then compressing the mixture in a hot mold.

B. P. 114,224/18 Turguand. An electric insulation for spark plugs consists of a material which holds the parts together without the use of gland nuts, screws, etc. It should expand or contract at the same rate as the body of the plug, e.g., Portland cement, sodium silicate, steatite, borax, and talc may be finely powdered and formed into a paste with water; this mixture hardens in drying without the aid of heat.

B. P. 122,295/18 Fullers Co. Electric cables are covered with rubber to which vegetable fiber such as hemp, jute, cotton, manilla or oakum has been added. The mixture is kneaded and worked together in a grinding or mixing machine before being placed in the forcing machine.

B. P. 124,669/18 British Westinghouse Co. Molded articles are made from a mixture of a hydraulic cement and a fusible material such as resin or pitch, preferably coal tar resins such as para-coumarone and para-indene; or varnish resins may be used. A fibrous binder such as asbestos and inert filler such as barytes may be added. The mixture is wetted, molded, and the articles are heated to melt the fusible material distributed in the mass.

B. P. 143,280/18 Elek-Tro-Material Ges. Electric conductors are insulated by fabric which has been impregnated with a solution of a cellulose combination, such as acetyl-, nitro- or formyl-cellulose and the like.

U. S. P. 1,296,076/19 Harding. An insulation for electric spark-plugs is formed

of rare earth oxides such as those of lanthanum, thorium, zirconium, etc. Partly refined compounds of monazite sand may be used. Only a small amount of thorium should be present. The mixture may be molded while slightly moist, or gelatinous lanthanum hydrate may be used as a binder together with the calcined oxide or air dry phosphate. If nitrates or chlorides of the metals are added the product becomes more dense after firing, at 16 or 20 Seger cone.

U. S. P. 1,299,706/19 Gudge. Inert fillers such as asbestos, wood flour or powdered silica are mixed with a binder of polymerized indene or coumarone products, by grinding with water in a ball mill, and the mixture may be molded into caps or cones for trolley hangers or other articles.

U. S. P. 1,299,798/19 Skinner. A composition suitable for cap and cone insulators for trolley lines is formed of Portland cement 40–45, resinous material containing a coumarone resin 5–20, asbestos 30–40, and barytes or other inert filler 10 parts. The ingredients are mixed with sufficient water to be molded without applying heat and permitted to set by immersing in cold water for several days. After the cement has set the articles are heated to 250 deg. to fuse the resin and render the material impervious to moisture.

U. S. P. 1,299,847/19 McCoy. A waterproof, heat resisting and electrical insulating material is formed of asbestos, Portland cement and a binder formed of coumarone and indene and their polymerization products.

U. S. P. 1,300,218/19 McCoy. A moldable composition for electrical insulation is formed of asbestos or other filler, a polymerizable vegetable oil such as China wood oil and a resinous binder comprising coumarone, indene and their products of partial polymerization. The oil and resinous binder are combined in such proportions that the shrinkage of one offsets the expansion on polymerization of the other. After molding, the product is heated to 100–200 degrees.

U. S. P. 1,303,753/19 Wright. A multi-ply material suitable for use in wireless installations is formed of sheets of paper duck or other fibrous material united together with a phenolic condensation product under heat and pressure.

U. S. P. 1,306,520/19 Burkley. An insulating composition suitable for use as a varnish upon fabrics where flexibility is desired is prepared by heating together gilsonite 5 and cylinder oil 6 parts, and at about 175 deg. blowing air or other oxidizing gas through the mixture under pressure of about 10 lbs. The temperature is raised to 225 deg. and the blowing continued for about 3 hrs.. when the flow point is about 150–160 deg. The product is a tough plastic homogeneous material.

U. S. P. 1,311,301/19 Tucker. An insulating and waterproofing mixture suitable for use on field magnets or armatures of electric motors is formed of red rosin 6 lbs. and linseed oil 1 pint.

U. S. P. 1,317,204/19 McCoy. An electric insulating composition suitable for use with paper, cloth or mica is formed of shellac 90 and naphthalene, melted together. Fillers such as asbestos, silica, or wood flour may be added.

U. S. P. 1,320,509/19 Swett. Insulators or similar articles are formed from mica fragments by distributing between successive layers of the fragments a fusible vitreous binder, subjecting the laminated material to pressure and to heat sufficient to fuse the binder and so proportioning the amount of the binder that the fragments after heating will be united at intermittent points of attachment. Lead borate (melting 365–370 deg.) may be used as the binder.

U. S. P. 1,320,637/19 Mosler. In producing mica insulators for spark plugs, mica disks are wetted with a resinous liquid such as shellac varnish, the disks are compressed while wet, dried to form a unitary mass and cut to the desired size.

U. S. P. 1,320,638/19 Mosler relates to a similar method in which alcohol is used instead of shellac varnish.

U. S. P. 1,323,026/19 Davis. An electric conductor is covered with paper or

other porous insulation, immersed in a bath of hot insulating material of high viscosity and then transferred to a cooling bath of liquid of lower viscosity.

U. S. P. 1,325,709/19 Bognar. An insulating coating containing asphalt, powdered glass and a softening agent such as castor oil is attached to a wire of copper or other metal by an intermediate layer of potassium silicate and sodium hydrate. An outer coating of cellulose acetate may also be employed.

B. P. 141,182/19 British-Thompson-Houston Co. Caps are attached to electric incandescent lamps or other glass bulbs by a cement which softens at a moderate temperature, e.g., 200 deg., and hardens at a higher temperature, e.g., 300 deg., the heating takes place during exhaustion of the bulb. A suitable cement consists of 1 part by weight of bakelite, 1 to 2 parts resin, and 8–10 parts marble dust as a filler to reduce shrinkage, with a solvent such as wood alcohol.

B. P. 141,987/19 Deleglise. A plastic composition which is a non-conductor of heat and electricity and is incombustible, is formed of 25 parts of fiber (paper, wood, rag, etc.,) 175 plaster, 45 gelatin, 10 tin oxide, and 110 of water mixed with 5 parts of formalin or sodium bichromate in 30 parts of water. Colors may be added.

Can. P. 191,264/19 Satow. An insulating compound consists of a liquid adhesive glue-like mass of glutinized vegetable protein, formaldehyde and a fibrous substance.

U. S. P. 1,329,094/20 Richard. An insulating material suitable for spark plugs or high voltage insulators is prepared by mixing silica 60, lime 2, alumina 20, magnesia 2, ferrous oxide 7, water and alkalies 4 and gradually heating it to 425–475 deg. to burn out the carbon (present in small amount in the clay), then rapidly increasing the temperature to contract the material and finally heating to the point of incipient fusion of the ferrous oxide, leaving the silica mainly unfused.

U. S. P. 1,330,440/20 Grunwald. Molded articles for electrical insulating are formed by mixing a phenol-formaldehyde condensation product and inert material such as asbestos or sawdust with non-solvent liquids such as water and benzine, the boiling point and vapor tension of which are close to those of water, molding the mixture and then heating under atmospheric pressure to harden it.

U. S. P. 1,331,519/20 Motta. A strong elastic material, suitable for electrical insulation or molded ornaments, etc., is formed of "paper paste" without size mixed with an equal weight of a mixture of calcium carbonate and magnesium silicate in equal amounts by volume.

U. S. P. 1,332,860/20 Wells. A material suitable for the manufacture of molded electrical insulators is formed of coumarone resin which may be mixed with shellac, asphalt, asbestos or other substances.

U. S. P. 1,343,040/20 Dantsizen. Zirconium oxide to the amount of about 15% is used in porcelain to improve its strength and electric resistance at high temperatures. The porcelain may be formed of clay 45, feldspar 35 and zirconium oxide 15 parts.

U. S. P. 1,345,057/20 Basset. An insulating and sealing composition is formed of hardened resin 30, bituminous material 45, wax 22 and resin oil, China wood oil or linseed oil 3%.

U. S. P. 1,346,397/20 Cavanagh. A fine, granular composition, suitable for the manufacture of electrical fittings or other articles of cold moldings is formed of asbestos or other comminuted inert material 83%, linseed oil or other drying oil about 10% and an asphaltic material 7%.

U. S. P. 1,346,874/20 Bellamy. A composition having a high electrical resistance at high temperatures, and suitable for insulating heating elements is formed of talc 50, silica sand 35, ball clay 5, and a "glass" 10 parts. The "glass" is a fusion product made from whiting 10.5, barium carbonate 20.7, clay 2.7, boric acid 52.2 and quartz 13.9 parts.

U. S. P. 1,349,389/20 Steinrok. Oolitic limestone or other natural stone is immersed in a heated solution of an aniline dye, heated to drive off the solvent of the dye and then treated with hot molten paraffin to render it suitable for use as an electrical insulation such as a switch-board backing.

B. P. 137,326/20 Bultemann. An electric insulating material is made from hydraulic stiffening bodies such as cement, gypsum, compounds of magnesium, etc., with an addition of fibrous material such as cellulose, asbestos, peat, slag-wool, glass-wool, viscose, etc., which are intimately mixed with fusible materials such as resins, pitches, hydrocarbons, bitumens, asphalts, sulphur, etc., and then treated with water, pressed, dried and heated.

B. P. 141,059/20 Moureu. Hard, insoluble resins are obtained by condensing phenols with acrolein in the presence of traces of inorganic or organic bases, etc. Instead of acrolein, its polymerization products may be employed, e.g., the acrolein resin described in 141,058. The products are non-conductors of electricity and may be molded, impregnated, etc.

B. P. 142,505/20 Thermos-Akt.-Ges. A resistance wire of ribbon is wound on a core of flexible insulating material, such as mica, coated with a plastic insulating layer such as asbestos mixed with oils, greases, lacs, etc. Powdered soapstone, talc, meerschaum, etc., are also suitable. The whole may finally be compressed.

B. P. 146,908/20 Champion Ignition Co. A composition for making the insulating portions of sparking-plugs consists of 60% raw clay, 30% calcined clay, some of which may be replaced by flint, and 10% feldspar.

U. S. P. 1,346,874/20 Bellamy and Sweely. A compound to be used for electrical insulation, comprising magnesium silicate, silica sand, sufficient clay to render it plastic, and sufficient glass to bind the whole into a homogeneous mass when fired at a temperature of approximately 1650 deg. F.

U. S. P. 1,358,366/20 Earle. Electric insulating and heat conducting material for electric heaters which consists in providing a granular base having high dielectric strength and thermal conductivity, mixing therewith a quantity of bonding material of high dielectric strength at the working temperatures of the electrical heaters in which the embedding material is to be used, and of high fusing point and capable when mixed with water of assuming a viscous condition to unite the granular base.

U. S. P. 1,362,563/20 Fahrig. A composition consisting substantially of 41% slate, 15% sulphur, 11% quartzite, 10% magnesite, 9% talc, 8% kaolin, 6% sericite, and a binder such as sodium silicate.

U. S. P. 1,368,753/21 Redman, Weith, and Brock. The process of producing a molded article, which comprises: mixing together a filler and a binder comprising, in proportions to afford about one methylene-amin substance, a phenolic body in unreacted condition and adapted to combine anhydrously with the methylene substance to form a condensation product, and a natural resin adapted to impart stiffness to the molding compound and subjecting the materials to a molding operation and heat treatment to form a body and transform it to a hard, resistant, and substantially infusible state.

U. S. P. 1,370,276/21 Buckman and Pritchard. A spark plug electric-insulator consisting of co-cemented particles or zircon.

U. S. P. 1,377,192/21 Edison. A method of producing material adapted for use in making molded articles, which consists in boiling a mixture of a resin, a drying oil and an oxidizing agent, then mixing the resulting product with a finely divided filler material and fibrous material with the application of heat cooling the mixture, and then grinding the mixture and subjecting the same to an oxidizing action.

U. S. P. 1,377,193/21 Edison. A sound record blank formed of a composition comprising a mixture of powdered China clay and fibrous material as a filler, held together by a binder comprising an oxidized resin.

B. P. 1,384,400/21 Nixon. A composition comprising a vulcanized mixture of approximately 10 parts of a caoutchouc-like substance and approximately 20 parts of finely divided vulcanized fiber.

U. S. P. 1,391,037/21 Young. Blocks for self-cookers composed of a kaolin blended with a pulverized fired kaolin and fired at a high temperature, having the heat retaining qualities of soapstone.

U. S. P. 1,401,953/22 Baekeland. A molding mixture comprising a plurality of condensation products of phenolic bodies and a substance containing a mobile methylene group, said mixture being characterized by the presence of a condensation product of ortho-cresol in excess of the proportion existing in condensation products derived from commercial cresol mixtures.

U. S. P. 1,402,750/22 Earle. An electrical insulating and heat-conducting material consisting of a highly compacted mass of grains of high dielectric strength and thermal conductivity connected by a bonding material consisting of non-vitrified Illinois kaolin, the degree of compactness being such as results from a pressure beyond which a decrease of dielectric strength would take place.

U. S. P. 1,409,953/22 Jeffery. A process of forming a ceramic body which consists in forming a raw batch of aluminous materials, flux and a clay mixture that when heated by itself will mature at the temperature at which the ceramic body matures, heating the raw batch at maturity of the clay mixture to form sillimanite from the clay and a glassy matrix that will dissolve substantially all the silica that splits from the clay in the formation of sillimanite from the clay.

U. S. P. 1,413,144/22 Weisberg. A molded electrical insulating compound comprising shellac and a resin formed from a polyhydric alcohol and a polybasic acid.

U. S. P. 1,415,076/22 Williams. An insulating sheath for electrical conductors comprising rubber and silica whose specific inductive capacity is not greater than 3.7.

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